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EDITORIAL

THE world's output of gold during 1920 is estimated by Samuel Montagu & Co. at approximately £70,000,000 par value, as compared with £75,000,000 in 1919, £79,000,000 in 1918, £88,000,000 in 1917, and £95,000,000 in 1916. During the same years, the British Empire's quota was £48,000,000, £50,000,000, £51,000,000, £56,000,000, and £60,000,000. There is no hope of this steady and continuous fall being checked.

LAST month we mentioned that some of the shareholders in Brunner, Mond & Co. objected to the company devoting any of its funds to the cause of University education. Since then similar protests have been made in connection with the subscription of £10,000 by Vickers, Ltd., to the endowment of the University of Sheffield. Some shareholders evidently do not appreciate the fact that in these modern businesses with a scientific basis a supply of high culture and education is a prime necessity.

THE memorial to the old students of Camborne School of Mines who fell in the war is to take the form of the purchase of a school playing-field capable of providing accommodation for football, cricket, tennis, and hockey. It is hoped to raise £1,000 for this purpose. The battle of life is still often won on the playing-fields. Many of our readers will be glad to have the opportunity for encouraging this important part of the mining students' curriculum, and they should communicate with the treasurer of the fund, Mr. Stanley B. White, at the Mining School.

DURING the course of a libel action last month, the Lord Chief Justice said to the editor of the offending journal: "I am a little impatient when I hear that these articles are written because it is a public duty; you did it in the ordinary course of business." The case was connected with an engineering problem, and the editor honestly believed that he was exposing a public grievance. Nevertheless he had to pay £500 damages. Naturally all editors are pleased that the Lord Chief is vacating the position to become Viceroy of India.

AMONG the recipients of New Year Honours are Mr. Bernard Oppenheimer, of Brighton diamond-factory fame, who has been made a baronet; Mr. Ernest Oppenheimer, the leading spirit in the Consolidated Mines Selection Company, the Rand Selection Corporation, and the Anglo-American Corporation of South Africa, who is made a knight; and Mr. Henry Strakosch, managing director in London of the Union Corporation, who is made a knight in recognition of his services to South Africa in connection with monetary problems. It is also announced that a knighthood has been conferred on Mr. H. W. A. Deterding, managing director of the Royal Dutch Petroleum Company.

DISCUSSION as to the site for the new London University buildings has been reopened by the proposal that the Senate shall consider the suitability of Holland Park, which has just been advertised for sale. This site is much larger than that in Bloomsbury, offered by the Government, and it is much cheaper. It is in a quieter neighbourhood, and it is in the heart of an admirable residential quarter. Though not in the centre of London, it is easily accessible from all parts by rail and omnibus, while its close proximity to the Imperial College, the Museums, and other educational institutions in South Kensington is a feature much in its favour. The objection to Kenwood, in Hampstead, was that the means of access were poor. Holland Park does not suffer from this disadvantage.

LAST month Mr. E. A. Brayley Hodgetts delivered a lecture before the Royal Society of Arts entitled: A Retrospect of the Personal Influence of Britons in Russia. The influence to which the lecturer referred was largely that devoted to the expansion of trade and industry. Of particular interest to mining engineers was his reference to the Urquhart family, which we quote herewith. "Another benefactor of Russia was Mr. Thomas Urquhart, M.Inst.C.E., locomotive superintendent of the Grazi-Tzaritzin railway in South Russia, who died as recently as 1904. He introduced a method of burning oil-fuel in the Grazi-Tzaritzin railway, with the result that by 1884 this form of fuel had supplanted coal over the whole system. Mr. F. V. Urquhart was the actual inventor of the method adopted, which he described in a paper read before the Institution of Mechanical Engineers. It is unnecessary to expatiate on the benefits conferred not only on Russia, but on the whole world by this satisfactory practical solution of the use of oil re-

siduals, hitherto waste, as fuel. Another member of this gifted family is Mr. Leslie Urquhart. His herculean work in organizing the mining industry of Siberia and Russia on a colossal scale is too well known to need comment." We take the liberty of adding Mr. Brayley Hodgetts' own name to the list of distinguished English engineers who have done notable work in Russia.

SINCE writing last month on the question "What is a Bank?" there have been two regrettable failures of institutions that were not legitimately entitled to this designation. The failure of Farrow's Bank came with dramatic suddenness just before Christmas. This is one of the two types of so-called banks to which reference was made last month. It was clearly not so much a bank as a benefit society. Such institutions cannot afford to pay interest on monthly balances on the scale usually adopted by them. As for the application of funds, they are not able to secure first-class business in competition with the big firms, and if they rely on gilt-edged securities they are quite unable to make good the heavy depreciation. We are sorry for Mr. Farrow, for he did great service in earlier days in drawing attention to abuses in money-lending, and we are loth to believe that there have been any irregularities in the conduct of the bank. The leading banks have once more advertised their willingness to take small deposits. As regards the Post Office Savings Bank, the weak point of this institution continues to be its refusal to take more than £50 in a year and more than £200 altogether. After a depositor has reached this maximum limit, he has to transfer into Consols or some such security. Then his capital begins to shrink. It is probable that the average depositor who has transferred in this way has, during the past twenty years, lost nearly as much capital eventually as if he had put his money in the Cheque Bank, the Birkbeck Bank, or Farrow's Bank. Presumably this maximum was fixed originally at the express desire of the regular banks, and in that case it may be taken that the latter did not consider business below this limit as being profitable to themselves. With dearer money, these conditions are no doubt different nowadays. Following the stoppage of Farrow's Bank, the Chancellor of the Exchequer announced in Parliament that the question of "What is a Bank?" will have to be discussed and settled in the House of Commons. When this matter is taken in hand, it will be desirable to have the publicly-expressed views of bankers as to the removal of the limit on Post Office deposits. The British-American Continental Bank, formerly Hannevig's, which has also failed, was of the type which we had in mind when the editorial last month was written, where the particular abuse to which the word was put referred rather to its application in the names of financial houses or promoting companies pure and simple. Such a use is just as deceptive as in the other case, though it operates in different circles. Both classes of institutions will require an equally close scrutiny whenever the House of Commons makes its investigations.

The Price of Metals.

Since writing last month on the slump in the price of metals, the situation has become even worse, copper, lead, zinc, and tin all showing further substantial falls. The price of zinc is far below the cost of production even under the most favourable conditions, while the prices of the other metals are much below the average cost. Not only are the prices low, but sales are restricted owing to the dull times in all the consuming trades. Every now and then a slight rally is observed in quotations in lead, zinc, and tin, but it is much to be feared that the cause is merely bear covering. The American copper producers have not been able to tempt consumers by progressive cuts in quotations, and stocks are accumulating. The Anaconda company is not paying its customary dividend; as one of the directors said, "they have plenty of copper but no gold." Rumour has it that the "porphyries" are considering a general closure. In British Columbia the Britannia and Canada Copper mines have been closed, owing to the fall in the metal, and the Granby and Consolidated are severely restricting operations. The Broken Hill mines are in an unusually unfortunate position. Just as they had started work once more, after an eighteen months' strike, the low level of prices has made it necessary to pause and wait for prices at which the products can be sold at a profit. The Electrolytic Zinc Company at Risdon, Tasmania, has suspended production, which had reached 25 tons per day, but the construction of the plant is being continued, and the Mount Read & Rosebery mines are being developed and the ore tested. And many other contractions of operations could be instanced, as a result of the slump in prices.

Whenever a slump in metals occurs and operations of established mines are curtailed, proposals for the development of new proper-

ties are not considered. Readers of the MAGAZINE often write to inquire why this should be so, arguing that the dull times when sales of output cannot be effected profitably should be devoted to what may be called dead work. They point out that new properties are generally floated in boom days, and that by the time there is an output the prices have reacted and the expected profits are not realized. The answer to these inquiries and suggestions is that investment in mining operations is largely a matter of temperament and of availability of funds. When metal prices are high and profits substantial, the quotations of the shares of established companies are at a maximum. Then the promoter and speculator sell out and have the funds for the flotation of new propositions. On the contrary, when times are dull the share market is depressed, and holdings can only be realized at a big loss, if at all. If that is so with individuals, how much more must it be the case with the promoting companies, who have to take steps to prevent their balance sheets from suffering owing to the serious shrinkage in the market value of their securities! It is thus clear that only the individual who has a long pocket independent of the market in mining shares could possibly consider the investment of funds in new mining ventures during the dull times, and unfortunately such individuals are few and far between.

Conditions in West Africa.

During the last year or two the mining companies operating in the Gold Coast Colony and in Nigeria have found a difficulty in keeping their native labour forces up to full requirements. In Nigeria the companies have not only had to stand up against the competition for labour coming from other industries and from the Government, but they also have suffered internally from the action of a few of their members in offering higher rates of remuneration than those generally recognized as suitable in connection with tin-mining operations. All endeavours to arrive at some concerted plan of action in this matter appear to have failed so far. In the Gold Coast Colony the cocoa plantations always offer serious rival attractions to the native worker, chiefly for the reason that the cocoa and chocolate manufacturer is one of those fortunate folks who have control of their own markets and can pass on any increase in costs to the consumer, thus having a strong pull over the producer of metals. A more serious competition, however, has more recently arisen owing to the large public works undertaken by the Government, particularly in the way of new railway construction and the re-building of old railways. The Government gets the mines both ways. To begin with, it is a competitor in securing labour for its railway work, and then, after construction is completed, it arranges its haulage rates on such a system that they virtually constitute a tax on the mines for Government revenue purposes. At the meetings of four of the West African companies held in December, Ashanti Goldfields, Taquah, Abosso, and Prestea Block A, the chairmen have drawn attention to this unfortunate position with regard to labour, and have publicly asked the Governor and those in authority at home to treat their ventures, which are all sound, established industries, with rather more complaisance. It may possibly be said that it is bad form to criticize a Colonial Government on points directly in connection with the critic's own interests, but in connection with West Africa there need be no such hesitancy in alleging that there is something wrong somewhere, for the mistakes made in the matter of paper currency are so obvious to every one that it is permissible to presume a lack of infallibility on the part of those in control. Thus every business man will back the gold-mining companies in their appeal to the Government authorities for fair treatment.

Whenever the question of native labour arises in any of the British dominions, it is necessary to remember the perennial difficulty of treating the inferior races with reasonable kindness and justice. The Aborigines Protection Society keeps a sharp eye open for anything like slavery or forced labour. It is right that this should be so, for otherwise a few unscrupulous men might bring about a relapse to conditions prevalent a hundred years ago. On the other hand, many dependable and unprejudiced observers have advocated some beneficent form of forced labour, for their gorge has risen at the sight of the indolent male living on the results of female exertions. In Tanganyika Territory there appears to be some scheme on hand for organizing native labour, which by some people may be considered as bordering on the "forced." Here the question is of unusual difficulty, for the chiefs are naturally harsh and false to their word, and the German influence was in the same direction. Mr. F. S. Joelson's book, just published, gives a very fair statement of conditions there. He admits that much patience will have to be exercised before a better mode of living is inculcated, but he sees in the natural sociability and good humour of the native a means for ultimate improvement. In West Africa the conditions under which the native lives are not

unfavourable, and there is only an unproved suspicion that the chiefs exercise undue pressure in making their subjects work for the Government and for the British companies and settlers. Our own impression is that the West African native is not an unwilling worker, and that, as regards the mines, the general question of the treatment of inferior races does not enter into the question at all.

The mine managers would naturally take steps to modify their plans whereby to reduce the amount of labour required, if such a course were possible. In the present case Ashanti Goldfields is the only company that could so rearrange the methods, and even here it is only the metallurgical treatment that can be modified. The ore, as readers who remember Mr. W. R. Feldtmann's article in the MAGAZINE for May, 1916, are aware, consists of quartz containing free gold and auriferous sulphides and also much graphite. The practice for the last ten years has been to dry-crush, roast, and cyanide. This plan was found to give a substantially higher recovery than wet-crushing, amalgamation, and cyaniding of sand and slime, though the cost was slightly higher. During the last year or two the cost has greatly increased, largely owing to the higher price of wood and of spares in the dry-crushers. It is now considered advisable to rearrange the treatment and adopt wet crushing, concentration, and roasting and cyaniding the concentrate. In this way there will be a great saving in wood fuel, as a comparatively small bulk of concentrate will have to be roasted, instead of the whole ore. The smaller scale of other operations will also bring advantages in reduced costs. Moreover, there will not be the same likelihood of stoppages, entire or partial, owing to scarcity of labour and fuel. It is clear that the recovery will not be so good, but here it is probable that the Minerals Separation process will prove useful in not only increasing the extraction of sulphides but also in saving much of the free gold. In fact, Ashanti Goldfields is one of the two companies trying this application of the process, as mentioned in the speech of the chairman of Minerals Separation held last month. The result of this rearrangement of the treatment process will be that, though the recovery will be lower, the reduction in costs will be great by comparison, and the profit will be improved. Unfortunately Taquah, Abosso, and Prestea Block A are not able to adopt modifications in metallurgical methods, and they will have to rely solely on their efforts to induce the Government to take steps to give them a steady and regular supply of labour.

Greenhow Hill.

Greenhow Hill's in Yorkshire,
Some way from the Minster City.
The Nidd flows by on the northern side,
To the south is Wharfedale, rich and wide,
A breezier spot you never spied.
But when begins my ditty,
Nearly thirty years ago,
To see the miners suffer so,
Through depression of trade, was a pity.
Lead! At ten or eleven pounds a ton,
It was clear that the mines could not be run
At a decent profit for anyone;
So the men had to leave the ore and chats,
From fifty different raikes and flats——

This fragmental parody of Robert Browning's well-known lines will serve to introduce to our readers a little book just published entitled: "T'ill an' T'Oade Uns upuv Greenho'," by Mr. Harold J. L. Bruff. If it had not been for the foregoing introductory jingle, readers would probably have imagined that the title was in the Haussa or perhaps the Siamese language. As a matter of fact it is broad Yorkshire for "The Hill and the Old Ones up at Greenhow."* The mining operations at Greenhow Hill were described in the MAGAZINE for May last by Mr. W. W. Varvill, who gave a historical account of the fortunes and misfortunes of this old mining district, as well as details of the present scheme for reviving the industry. Mr. Varvill told us that this work of resuscitation was due largely to Mr. Harold Bruff, a resident in the neighbourhood, who is one of the engineers of the North Eastern Railway. The driving of an aqueduct tunnel to supply Bradford with water from new reservoirs in the upper part of Nidderdale had proved the continuation of the lead formations and veins in depth, thus warranting considerable capital expenditure in connection with new mining ventures. In this little book now published we find Mr. Bruff to be one of those few people of position who really try to understand the miners and other working men, and to appreciate the innate goodness of heart and honesty of purpose of the average worker. But he does blame the miner for not being able to regard his relationship to his work as having influence on anything or anybody but himself. That the miner should work only as long as it suits him personally is not taken as an indication of wickedness; but Mr. Bruff puts it clearly to him that this attitude is the chief obstacle to the restoration of an ancient industry. Perhaps the author will be able to instil in the minds of the men the true economic principle.

* York: T. A. J. Waddington, *Yorkshire News* Office, Mansfield Street; price 3s. [illegible]d. net.

Greenhow Hill is one of the highest villages in England, and stands on the limestone moors between the two beautiful valleys of the Nidd and Wharfe. It is distinctly breezy at all times, and in winter the snow-drifts are often alarming. Yet the miners belong to the cult of the open window, and thus escape the tubercular and other troubles characteristic of Cornwall and North Wales. They are also believers in good feeding, and they looked askance at the miner in their midst from Cornwall, who lived on tea, bread, and marge, and grilled his mid-day rasher of bacon under the boiler furnace, and who ultimately developed scurvy. Many of them are characteristically tall and strong, and Mr. Bruff, who is himself half a Norwegian, sees in them the strain introduced by settlers from among the old Norse raiders.

The limestone in the backbone of the Pennine Chain is full of underground water courses, and both water and air ebb and flow with eerie effect. Unexplainable noises give rise to many ghost stories, which generally take the form of visits from dead friends or of premonitory warnings of disaster. The existence of piskies or gnomes forms no part of their superstitions. On the other hand, the effective reading of a chapter of the Bible has served to allay the evil spirit and restore courage to the miners. Some of the ghostly appearances, however, are not based on uncanny sounds, for candles and clogs can be seen at times moving about, and of these there can be no physical explanation. It is possible that the belief in these visions has come down from the early days of Scandinavian influence. For instance, the "bar-gest," or ghost of a bear, is a spirit that haunts the falls in the upper Nidd, as the White Lady haunted the falls near Melrose, according to Sir Walter Scott in the "Monastery." Also the "telegbaster," the being that "flees about in t'mornins with a crooked neb," has a family likeness to the Norwegian "deilegast," a departed spirit that may easily be mistaken for an owl.

Mr. Bruft's book contains character sketches of many men and women thinly disguised under homely names, and many of their doings are in connection with mining operations. Naturally the tragic events recorded have to do with the inevitable accidents in mines, and in all cases some act of true heroism and thoughtfulness is recorded. Joss and Bin and Kit and A'nt Hannah are characters such as are found in the pages of Quiller Couch. Many of their adventures reflect the dangers of mining. For instance, Kit tells how he worked in a mine where it was the custom that one shift of men were let down 40 fathoms for their ten hours' work and could not be brought to the surface again until the other shift arrived in due course. Many a time the air became so foul that the candles went out and the men had to grope their way in the dark to the foot of the shaft to wait in the damp and drippings for their relief in due course. The worst of it was that they received no pay for these hours of wretched idleness.

In another part of the book, Henry tells how the older and more experienced men among the miners, who had also the responsibility of managers as regards following a vein or leader, used to sit on their clog heels underground, chewing their bacca, and turning over in their minds the various problems before them. To help their cogitations they played with lumps of clay between their palms, and it was necessary that the clay should contain no grit, as the grit would entirely discompose their train of thought. So important was it that the clay should be perfectly smooth, that old miners went out of their way to obtain the best qualities, and each man would carefully keep secret the source of his supply.

One of the most tragic stories of the many in the book refers to a blasting accident, where two young miners were blown to bits. Their fellow miners collected the remains to the best of their ability, and placed them in coffins. When the coffins were brought to the church to await burial, the parson refused entrance, because the boys had been christened by a lay preacher, though after a long argument the remains were allowed to rest in the porch overnight. Old Joss said he did not see why there should be such a fuss about Christians being received into a church under such circumstances, when black men and real heathens were allowed to see the sights at York Minster, St. Paul's Cathedral, and even Westminster Abbey.

Books on the human side of mining are so scarce that when they appear they are worthy of special attention. Mr. Bruff's book provided us with Christmas reading of the right sort, and it can be recommended to all mining men for perusal in the same spirit. As we have said, it is only a small book, but it is closely printed and full of good things. One day perhaps Mr. Bruff will feel encouraged to elaborate and expand, and to give illustrations and even maps, though, of course, maps are only a weakness of the Editor of THE MINING MAGAZINE and may not be really necessary.

REVIEW OF MINING

Introduction.—The general depression of trade is becoming accentuated and the prices of metals have fallen so low that mining operations are hardly profitable anywhere. The exception is gold mining, and here in many cases it is only the premium that preserves the mines from failure.

Transvaal.—The dividends declared by the Transvaal gold mines for the latter half of 1920 are given in the accompanying table. The rise in the gold premium and its comparative steadiness account for a notable increase in the profits. The advance in the working cost, which has been characteristic of the last few years, has slackened somewhat, but expenses are still on the up grade. Unexpected reappearances in the dividend list are Kleinfontein and Knight Central.

The total dividends declared by mines on the Rand during the year amounted to £8,314,300, as compared with £6,287,200 in 1919, £5,330,000 in 1918, and £6,556,000 in 1917. Of the total, £5,185,500 came from mines in the Far East Rand.

	1st half, 1919.	2nd half, 1919.	1st half, 1920.	2nd half, 1920.
	s. d.	s. d.	s d.	s d.
Brakpan	2 6	3 0	3 0	6 0
City Deep	2 0	2 9	2 6	4 0
Consolidated Langlaagte	1 0	1 6	1 0	1 6
Consolidated Main Reef	6	1 3	1 3	1 9
Crown Mines (10s.)	6	3 6	2 9	5 0
Ferreira Deep	1 6	1 0	2 0	2 6
Geduld	—	*a*	1 6	2 0
Geldenhuis Deep	6	1 6	6	2 6
Government Areas	3 6	4 0	4 0	6 0
Kleinfontein	—	—	—	1 0
Knight Central		—	—	1 6
Knights Deep	—	9	—	—
Langlaagte Estate	1 6	1 6	1 0	1 6
Meyer & Charlton	10 0	14 0	10 0	14 0
Modderfontein (10s.)	26 0†	30 0†	4 6	5 9
Modderfontein B (5s.)	9 0**	9 6**	6 6**	2 6
Modderfontein Deep (5s.)	10 0††*c*	3 3	3 0	4 3
New Primrose	1 0	1 0	—	1 0
New Unified	1 0	1 0	1 0	2 0
Nourse Mines	—	9	9	1 0
Robinson Deep "A" (1s.)	—		2 0	
Robinson Gold (£5)	5 0*b*	2 6	1 0	2 0
Rose Deep	1 6	3 6	2 0	3 6
Simmer & Jack	3	6	—	6
Springs Mines	—	—	1 0	3 0
Sub-Nigel	1 0	1 0	1 0	1 6
Van Ryn	1 0	1 6*	1 6*	1 6
Van Ryn Deep	4 6	5 0‡	5 0	8 0
Village Deep	—	1 3	6	1 6
Village Main Reef	4 6§	2 0	—	—
Witwatersrand Gold	1 0	1 0	1 0	3 0
Wolhuter	6	6	1 3	1 3

† On old £4 shares. †† On old £1 shares. *a* Scrip distribution equal to 16%. *b* Bonus. * Free of tax. ‡ Also Scrip. *c* Partly in Scrip. § Paid in Scrip. ** On old £1 shares.

The north shaft at New State Areas has cut the reef at a depth of 3,578 ft. Here the reef is faulted and disturbed by numerous quartz intrusions, and the assay-value is only 1 dwt. over 6 in. It will be remembered that the south shaft cut the reef in October, and that the assay-value averaged 89·8 dwt. over 18·9 in.

The chairman of the Johannesburg Consolidated Investment Company devoted a large part of his address at the recent shareholders' meeting to the company's new ventures in coal-mining. The interests acquired are the Cape and Carlchew collieries, which have been amalgamated as the Consolidated Collieries, Ltd., the Witrand and the Springs collieries, in the Transvaal, and the Natal Cambrian and Burnside Central collieries, in Natal. Of these, the collieries in the Transvaal and the Cape, and the Natal Cambrian, are producers, but the scale of operations can be greatly extended. The Burnside is not yet producing. In order to facilitate distribution of output, the company has acquired the business of J. R. Macduff and Co., Ltd., and introduced new capital. The chairman's comments on the dilatory methods of the Government railways are likely to make those in authority sit up and take notice.

The report of the Rooiberg Minerals Development Co., operating lode-tin properties north of Pretoria, shows that the mill was closed from May, 1919, to January, 1920, during which time attention was devoted to development. From the period of resumption to the end of June, the mill treated 15,427 tons of ore, and 12,056 tons of accumulated middlings and tailings. The total yield of concentrates, including some won by washing alluvial ground, was 330 tons. The Blaauwbank property recently acquired has been abandoned, and a trial is now being made on the Weynek property. At the original mines no new ore-bodies have been discovered lately. The profit for the year was £7,663, and £9,000 was distributed as dividend.

Diamonds.—The De Beers Consolidated has adopted the crushing system for its blue ground instead of weathering, and recently ordered gyratory crushers capable of disintegrating 40,000 loads per day. It will be remembered that the Premier company employed crushing from the commencement, and thus saved a considerable lock-up of capital. At one time it was thought by many that crushing would injure and break the diamonds, but apparently this does not form an economic feature of the matter. The crushing plant at Bultfontein has already been completed and should start in March. The plants for the Dutoitspan and Wesselton mines will not be at work for eighteen months.

Congo State.—It is announced that the Union Minière is adopting the Garred Cavers system of employing pulverized coal in the blast in their copper furnaces, with the object of reducing the coke consumption. This process was described in the MAGAZINE for September, 1919.

Rhodesia — The dividends declared by Rhodesian mining companies during 1920 exceeded one million pounds, the figures being nearly double those of the year before, and more than £300,000 higher those of 1917, the previous highest figures. The premium on gold largely accounted for this increase, but asbestos production was also an important factor.

The Cam & Motor announces the starting of the reorganized crushing and concentration plant. The flotation section will be at work in a week or two.

West Africa.—The labour position at the West African gold mines has become worse lately, owing to the natives being provided with counter-attractions in the form of Government railway work. Reference to this matter is made in another part of this issue. At the Taquah mine the lode has folded upward, and it has been followed by rises for 250 ft. Drilling is now in progress to locate its continuance. At the Abosso, developments have been good recently, and it is therefore disappointing to find that, owing to shortage of labour, it has not been possible to keep the mill going full time. The Abosso company has recently acquired the property of the Wassau company adjoining on the north, and situated on the dip of the Abosso lode.

The Goldfields of Eastern Akkim, Ltd., one of the Tarbutt group, has issued a subsidiary called Akim Alluvials, Ltd., with a capital of £150,000, for the purpose of acquiring mining rights over gold and diamond alluvial deposits in West Africa. In the report by Mr. John Saxton it is stated that a "shaft has been sunk 26 ft. on kimberlite in yellow ground yielding half a carat per cubic yard at that depth."

Nigeria.—Last month we recorded that the Jantar had absorbed the Kuru Syndicate and Kuru South. The company has since issued its yearly report to September 30, from which it appears that a loss would have been made had not a refund been received of excess profits duty previously paid. At the meeting of shareholders the chairman said the company had £12,000 worth of tin concentrate unsold and very little cash. As it is not possible nowadays to obtain the financial help customary on such occasions, it becomes necessary to make an issue of £25,000 preference shares or debentures in order to put the company on a sound basis.

The Northern Nigeria (Bauchi) Tin Mines is considering the ways and means of raising the additional capital required for completing the Kwall Falls hydro-electric installation. This plant is costing much more than originally estimated, owing to the continued advance in the price of materials and labour. The sum named is £125,000. The company already has a large preference share issue, and has in addition a loan of £45,000 covered by a debenture, the latter having been raised in connection with the hydro-electric plant. It is doubtful whether the chief shareholders would be in a position to provide further funds by a reconstruction, but it may be possible to raise the money by the issue of further debentures. Another course is to postpone the completion of the plant until the money, metal, and share markets improve. The company has extensive proved lands that can be profitably worked by present methods. In fact the past year's output was 100 tons greater than that of the year before. So the policy of delay in connection with the new power-plant may be the best under the circumstances.

Australia.—It is unfortunate that the slump in metal prices should come just as the Broken Hill mines had resumed work after a prolonged strike. The advisability of continuing operations is being seriously considered, and some of the mines, at any rate, will close down. At Kalgoorlie another stoppage is reported, again owing to the lack of fire-wood. The whole community is also upset with railway and shipping stoppages.

The further rise of wages in the West Australian goldfields, as awarded by the Arbitration Court, will have a serious effect on the industry. There is to be an immediate increase of 3s. 6d. per shift in the minimum average wage, and the machine miners' rate is advanced 4s. 6d. per shift. The working week is to be 48 hours for surface employees, and 44 hours for underground workers. The shift in rises, and in wet shafts and winzes, is to be 6 hours. A fortnight's holiday on full pay is to be given annually.

A new bill is being introduced by the West Australian Minister of Mines relating to tributing operations. It provides that before any royalties are deducted from the gold won, the tributers must have received £3 per week per man.

The Hampden Cloncurry reports a loss of £49,031 during the half-year ended August 31, owing chiefly to the fact that the products on

hand at the beginning of the period were sold at lower prices than the valuation. During the half-year the yield was 2,070 tons of copper, containing 1,152 oz. gold and 12,473 oz. silver. All operations at the MacGregor group of mines have been discontinued,owing to the low-grade ores not being able to stand the increased mining costs. Since the above cable message was received another has come to hand announcing that all operations have been suspended owing to the low price of copper.

It will be remembered that the directors of Mount Elliott gave an option on the whole of the company's copper properties to Hayden, Stone & Co., of Boston, who sent Mr. Edwin S. Berry, of the firm of Yeatman & Berry, to see if the great reserves of low-grade ores could be worked to profit. He reported against the project, owing to the impossibility of concentration, and the option lapsed. Mr. W. H. Corbould, the company's consulting engineer, has since brought forward a leaching scheme, based on the practice at New Cornelia, Arizona. The company will require a large amount of new capital to carry out this proposal, and in addition it will be necessary for a railway to be built to Argylla and Mount Oxide. Railway construction in Queensland is in the hands of the Government, and as the latter cannot raise funds easily for any purpose the outlook for a railway is not bright.

According to the cabled report of the Mount Morgan company for the half-year ended November, the copper unsold and in process of refining amounted to 5,035 tons. This state of congestion is largely due to accumulations caused by the shipping strike and by a strike at the Port Kembla refinery. Consequently it is not possible to declare any dividend. During the period under review, 172,343 tons of ore was mined, of which 106,895 tons was concentrated, yielding 39,436 tons of concentrates, while the rest was sent direct to the smelters. The smelters treated 58,868 tons of ore and 34,396 tons of concentrates, and produced blister copper containing 3,431 tons of copper and 52,686 oz. of gold. The company announces participation, in association with the Electrolytic Refining & Smelting Co., of Port Kembla, in the formation of the Australian Fertilizers Proprietary, which has been incorporated with a capital of £500,000. The refining company desired to have its own source of sulphuric acid, and the opportunity presented itself to start an acid works on a large scale, using the acid in the manufacture of superphosphates. The fertilizer works is now in course of erection at Port Kembla, and the first unit, with a yearly capacity of 30,000 to 40,000 tons of superphosphate, is expected to be completed next July.

The Chillagoe Company handed over its copper properties and railway to the Queensland Government in 1919, and now only owns the Mount Mulligan coal areas. The shareholders have just agreed to the raising of new capital, which it is expected will be at the rate of 3s. per 10s. share, for the purpose of clearing off its indebtedness to the Government and of completing the coke-oven installation.

New Zealand.—It is announced that the Talisman mine is to be abandoned, and all underground plant is being withdrawn. This mine contained rich ore in narrow veins and made handsome profits over a series of years. A year ago the reserves came to an end, and subsequent exploration by diamond-drill has not disclosed any further deposits of value.

India.—The reconstruction of the Nundydroog company, to which reference was made in the November issue, has been successfully carried through. Shareholders have generally responded to the call, and for the few shares not taken up by holders there have been large inquiries from elsewhere.

Another favourable event in the Indian group of gold mines is the re-entry into the dividend list of Champion Reef, which has just declared a dividend of 4d. per 2s. 6d. share. The last distribution was the final dividend of 4d. for the year ended September 30, 1918.

Malaya.—In order to stabilize the local tin-mining industry, the Government of the Federated Malay States has fixed a minimum price of tin, the basis being 110 dollars per picul. It will be remembered that two years ago the Government took somewhat similar steps for protecting the industry, the plan then being to buy at the official quotation whenever there was a difficulty of selling in the open market. A committee has been appointed to inquire into the cost of production of tin in the Federated Malay States.

The Government report on tin-mining in the Federated Malay States during 1919 has only just been published, and most of the information is therefore rather belated. It is interesting to note that 68% of the tin output comes from mines under Chinese control, as compared with 74% in 1913. Also, of the 36,935 tons of tin exported, 5,137 tons was in the form of metal produced at native smelters, while 31,798 tons was contained in concentrates sent to the English smelters at Singapore and Penang. The native smelters appear to have secured a larger share of the ore than previously.

Newfoundland.—The Anglo-Persian Oil Company has received a concession from the Newfoundland Government giving it sole right for five years to prospect for oil in all ungranted Crown lands. The existence of petroleum at Parsons Pond on the west side of the island has been known for over a hundred years. From 1867 onward a number of projects have been started and many wells were sunk, but the venturers were generally short of capital, with the result that commercial failures were recorded. The petroleum is found at an unusually low geological horizon, the rocks containing it belonging to the Lower Silurians.

Mexico.—The fall in the price of silver is causing great concern among many of the mining companies operating in Mexico. The directors of the Mexico Mines of El Oro have decided for this reason to postpone the issue of new capital to which reference was made last month. It will be remembered that the object of the issue was to complete the purchase of a second property in which the company is already largely interested.

Another favourable cable has been received from the Esperanza mine at El Oro with regard to developments on the fifth level. During the week ended December 31, the north drive was extended 13 ft., in which the lode averaged 8 oz. of gold and 105 oz. of silver over 16 in. of width.

Colombia.—As mentioned in last issue, the first dredge of the British Platinum & Gold Corporation has started work, and the second is in course of shipment. It has been decided to defer the placing of the contract for No. 3 owing to the high prices asked for this class of work. Messrs. Inder, Henderson, & Dixon report that systematic prospecting of the Cimarronas property has been completed. The limits of a deep channel have been ascertained, as also have been those of some blocks of shallower ground. In the deep lead it is estimated that there are 1,828,406 cu. yd., averaging 12·265d. per yard, and in the shallow leads 328,052 cu. yd., averaging 17·839d. per yard, the price of crude platinum being taken at £12 per ounce. It is intended now to prospect on the other properties belonging to the company.

Venezuela.—The South American Copper Syndicate has been engaged in litigation in the United States owing to the New York buyers of the syndicate's products desiring to evade their contract. The contract was made early in 1916 and covered the eight years from 1918 to 1925 inclusive. One of the terms was that the buyers should provide the freight. Owing to the increased cost of freight and refining, the buying firm attempted to repudiate its obligations under the contract. The company won its case in the court of first instance. The buyers appealed, and the case was re-argued. News is now to hand that the company's case is upheld by the Court of Appeal. The judgment is of considerable importance to the company, for it thus is able to avoid the present heavy charges made by smelters and refiners.

Chile.—Owing to the low price of copper, the Poderosa mines are reducing the shipments of ore and work is being devoted chiefly to development.

China.—The Chinese Engineering and Mining Company is about to start an iron and steel enterprise in Chinwangtao, the port near the company's coal mines. The enterprise is to be conducted jointly with the Lanchow Mining Co., the Chinese-owned coal-mining company that works adjoining lands and sells its coal through the same organization. The iron mines are near the Yang-tse-kiang, and Mr. Frank Merricks has reported that they contain large quantities of high-grade ore. The companies have made a contract with the owners of the deposit to buy four million tons of ore. Other sources of supply are being investigated. Designs for a blast-furnace are in course of preparation by Mr. F. W. Harbord.

Spain.—The strike at the Rio Tinto mines has been settled, by the intervention of the Minister of War, after lasting six months, but there is still a good deal of unrest in various quarters.

Roumania.—The Court of Appeal has reversed the decision of Mr. Justice Darling, who awarded the Roumanian Consolidated Oilfields the sum of £1,255,513 as compensation for the destruction of their property during the war. The Crown contended that application for compensation should not have been made to the British Government but to the Roumanian Government. It must be confessed that the attitude of the Crown and the result of the appeal caused considerable surprise, for it was always understood, as recorded in our pages in October, 1917, that Sir John Norton-Griffiths was sent by the British Government to destroy the wells, and that he did so after protest from the Roumanian authorities.

Spitsbergen.—An expedition of scientists from Oxford University to Spitsbergen is in course of preparation. Among their number there will be geologists and paleontologists. Two parties are to go out in sealing sloops in June and July next. The expedition is to be conducted with commendable economy.

KELANTAN AND ITS NATURAL RESOURCES.

By V. F. STANLEY LOW, M.Inst.M.M.

The author gives an account of one of the lesser known States of the Malay Peninsula, and tells of his experiences there during a recent visit.

KELANTAN AND ITS PEOPLE.—The two least known or explored of the protected states of the Malay Peninsula are Kelantan and Trengganu. The states of the Malay Peninsula are so frequently spoken of as the "Federated Malay States" that perhaps it would be as well to state that only four of them are federated. British Malaya is divided into the British colony of the Straits Settlements (Singapore, Penang, Wellesley, the Dind-dings, and Malacca), the Federated Malay States (Perak, Pahang, Selangor, and Negri Sembilan), and five other protected native states (Kelantan, Trengganu, Kedah, Perlis, and Johore), all of which acknowledge Great Britain as suzerain. In each of the five last-mentioned states Great Britain is represented by an "adviser" appointed from the civil service of the Federated Malay States; and the native rulers of the various states are expected to follow the advice given by their respective "advisers." The Governor of the Straits Settlements is also High Commissioner for each of the native states, being represented in the Federated Malay States by a Chief Secretary, who resides at the capital, Kuala Lumpur.

There appears to be uncertainty as to the origin of the people generally classed under the title "Malays" who form the bulk of the population. By many these are thought to have come from Sumatra; but, no doubt, many people also came from Siam, Java, and the neighbouring islands. The so-called Malay is able to cultivate his land and grow rice, maize, fruit, and vegetables; he is a skilled boatbuilder and boatman; he can weave silk and cotton; but he seldom produces an output of any of these articles beyond the immediate wants of himself and his family; and so great has been the kindness of Providence in furnishing rich soil, favourable climate, abundant fruits, and fish-teeming rivers that the life of the ulu, or up-country, Malay is one of comparative calm, ease, and almost luxury. The Malay who has not come into much contact with members of other nations is by nature courteously polite, but shy; and nearly every Malay is a born liar, who finds no shame when his lies are exposed.

As a worker on the river, poling or paddling his native craft, the Malay is an untiring expert, and he is also good at jungle clearing; but he soon tires of regular employment unless it has something to do with engines or machinery. He is, therefore, of but little use for work on mine or plantation unless in charge of a launch or motor-car, of which he soon becomes a careful driver; and in these departments he frequently leaves his Chinese competitor far behind.

MAP OF MALAY PENINSULA.
Showing the Various States and Political Divisions.

Only a few of the true aboriginals—the Saki—still remain. The Saki, as found in the Eastern states, is, generally speaking, very shy and holds no converse with members of other races, be they white, black, or yellow. He does no cultivation, but leads a nomadic life, gaining his sustenance from roots, fish, and birds, the last of which he brings down with darts discharged from a blowpipe some seven feet in length. Being a nomad he builds only temporary shelters, composed of palm fronds placed in the ground in a circle with tips inclined toward the centre so as to form a low

shelter, in appearance like an upturned bowl. Sometimes the palm fronds are placed in a straight line so as to form a simple break-wind, the inclined and overhanging tips being sufficient to ward off the drips from the jungle of the heavy tropical dews. The Saki inhabiting the banks of the Nenggiri river are said to have become more settled. I have not come into contact with the Nenggiri Saki; but such Malays as I have met who have been far up that river have spoken of the Saki there as being well-developed men, skilful boatmen, and good workers.

HISTORY AND GOVERNMENT.—British Malaya is a land without history or historical remains. Europeans have lived on the coast for at least four hundred years; but until 1860 there was only one white man known to be resident inland. Such development as had taken place prior to recent years was due to Chinese adventurers, and, in a less degree, to the Siamese; the Portuguese and Dutch appear to have allowed the country to lie dormant. The time of entry of the Chinese is unknown; but the turn of the tide came when the British took definite action in 1873. Almost the first matter in the native states to receive attention was that of state finances. By abolishing many of the taxes on exports and by taxing the importation of opium, spirits, and such like; by charging rents for mining and agricultural lands, and by seeing that the money so obtained was properly expended, the financial chaos which previously existed was straightened out to such good effect that, as an example, the Federated Malay States are now become wealthy enough to make state loans to their neighbours, and at the end of 1918 had a surplus of over twelve million pounds sterling.

When, in 1903, the first British Adviser was appointed to Kelantan, which then belonged to Siam, he found everything political in a rotten condition. The ruling Rajah, through the plotting of his own family (the usual practice in Malaya) had lost practically all power of governing; such taxes as it was possible to gather were not used for the benefit of the state; and no accounts of expenditure were kept. Under an agreement with Siam, Kelantan in 1909 became an independent state under the protection of Great Britain. Since then the ruling native potentate has been raised in dignity from Rajah to Sultan and governs the state with the assistance of a Council and under the advice of a resident British Adviser.

Kota Bharu, the capital and seat of government, has two courts, the principal one being under the presidency of a British magistrate and the minor one under that of one of the Malay aristocracy. District Officers, appointed from the British side of the civil service of the Federated Malay States, attend to the magistracy of the country districts and reside at Pasir Puteh and Kuala Krai. The officers in charge of the Lands Office and of the Survey Department are British, as are also the Chief Police Officer and his Chief Inspector. Most of the clerical work is performed by natives from India, China, and Ceylon, assisted by a fair proportion of local Malays. The police force is composed of Sikhs and Malays. The Sikhs are purely military police; all civil police work is performed by Malays under Malay inspectors appointed by the Chief Police Officer. All inspectors must pass an examination in English before appointment. There are three British doctors, and one Chinese doctor holding British diplomas, who are assisted in the various native hospitals by trained dressers drawn from India and China. There is no hospital accommodation for white people except at the private hospital of the Duff Development Company at Kuala Lebir.

COMMUNICATIONS.—Kelantan has a coast line of 45 miles and an area of 5,870 square miles; its greatest width is perhaps 75 miles. The country is flat along the coastal district; and it is said that three distinct old sea beaches may be traced, showing the rapid encroachment of the land on the sea due to the silt deposited by the torrential flow of the rivers during the rainy season. At a distance from the sea varying from 10 to 20 miles the land begins to rise and then quickly becomes mountainous, culminating on the southern boundary in Gunong Tahan—the Forbidden Mountain—7,186 ft. above sea level. This is about the highest peak in Malaya. The state is well watered throughout its length and breadth by rivers. The main river, the Kelantan, runs approximately north and is formed some 62 miles inland by the junction of the Galas and Lebir rivers. The main tributaries of the Kelantan are the Sokor and Nal rivers; but these two are not nearly so important as the tributaries of the Galas—the Pergau and the Nenggiri—which enter that river some 80 and 92 miles respectively from the coast. The Lebir has tributaries of fair size in the San, the Sok, and the Rek.

The approach from the sea to Tumpat, the port of Kelantan, is bad, owing to the rapid encroachment of the land. A few years ago the custom house was situated on a coconut-grown island opposite the town of Tumpat and

not far from the mouth of the Kelantan river. In those days coastal steamers on the way from Siam to Singapore entered an eastern channel, anchored behind the custom house, unloaded and reloaded, and then proceeded to sea through the western channel. Now everything has been changed, for the monsoons have made a low sandbank of the island which has spread out to such effect as to have formed a lagoon across the mouth of the river, leaving only a small opening for the passage of launches and lighters. The custom house and the coconuts have disappeared; and steamers must anchor outside at a distance of at least two miles from the landing place. In the monsoonal season Kelantan has been cut off entirely from outside communication for three weeks or a month at a time by the heavy seas breaking at the mouth of the only channel available. It is difficult to forecast what will happen unless a monsoon of exceptional violence follows the example of some of its predecessors and washes a new channel or entirely removes the sand-bank, because the lagoon which has been formed is being filled so rapidly with silt from the river that even the shallow-draught launches which traverse the rivers already find it difficult to cross the lagoon from the river mouth to the Tumpat jetty.

A railway is under construction and will eventually connect the Siamese system with that of the Federated Malay States by traversing the length of Kelantan and making a junction at Kuala Lipis in Pahang. For carrying out the necessary extensions in Siam to connect with Kelantan, and also to make another such extension on the west coast, the Government of the Federated Malay States advanced four million pounds sterling to Siam. For a considerable time past trains have been running from Tumpat to Tanah Merah, 36 miles inland; and a branch line has also been completed from Pasir Mas on this line to the border of Siam, where a junction should have been completed by this time with the Siamese system. It will be eight years or more before a junction with Kuala Lipis will be made, as there is much tunnelling to be done between Kuala Lebir and the Pahang border. So strange is the policy of the Federated Malay States Government in some things that their railway department, which is carrying on the construction of the line in Kelantan, states that neither passengers nor goods will be carried beyond the present terminus, Tanah Merah, until the whole line to Kuala Lipis has been completed. Thus will the development of Kelantan be delayed by officialdom.

THE LEBIR RIVER, AT A POINT ABOUT 78 MILES FROM THE COAST.

Kota Bharu may be reached in six miles by rail and ferry from Tumpat or in eleven miles by launch or native craft. Above Kota Bharu the Kelantan river is navigable throughout its length at all seasons by light-draught launches and lighters, as are also the Lebir for twenty miles and the Galas for 20 miles above their junction at Kuala Lebir, so that one may proceed upstream some 82 miles by branching off at Kuala Lebir into either the Lebir or Galas rivers. Beyond that distance the rivers are broken by rocks, rapids, shallows, and sandbanks; and for the two months immediately preceding the rainy season are passable for only the lightest of native craft. During a great part of the rainy season, when the rivers may be expected to rise anywhere from sixteen to thirty feet above normal level, it is practically impossible for native craft to go upstream, because the flow of the river is too rapid for oars or paddles to be effective, and there is too great a depth of water for poling; the thick jungle prevents the passage of boats along the edges of the flooded area. Therefore anyone engaged in prospecting for gold on the upper Galas, or for tin near the source of the Nenggiri, could quite easily be cut off from efficient supplies of food and mining stores for four or five months in the year.

As Kelantan possesses only a very meagre mileage of roads, and as these roads are only lightly constructed and badly maintained, and are designed to serve the flat lands mostly planted with rice, very little development, from a mining point of view, can be expected until the railway has been opened, roads made, and tracks cut to districts now practically inaccessible.

The census of 1911 showed Kelantan to have a population of 286,751, of which 269,000 were Malays and 10,000 Chinese.

GEOLOGY.—Very little is known geologically of Kelantan; and there is no work published which deals with Malaya as a whole or the whole of any one state. Kelantan is so deeply covered with soil, so much of the country is dense jungle, and the outcrops of rocks are so few that geological examination and prospecting for minerals are difficult matters. The main backbone of mountains, which runs north-west to south-east down the Malay Peninsula, is composed of granite, and there are many subsidiary ranges east and west of this. It is stated that the Tahan range, on the boundary of Pahang and Kelantan, is composed of conglomerates, quartzite, and shale, while in Pahang conglomerate and sandstone ridges are found at the foot of the main granite range. A belt of limestone is said to cross the peninsula from Malacca to the coast of Kelantan; but the limits of this belt, if it exists, have not been demarcated. There are many outcrops of limestone; and limestone hills and cliffs, containing large caves whose floors are deep in the guano of bats, are frequently met with in Kelantan; but so little survey work and exploration have been done that the extent of the limestone belt is at present unknown. Even the maps which have been supplied by the Government have been found to be grossly inaccurate; and my own experience has been that the least inaccurate maps are those which were prepared by the Duff Development Company for its private use. The most reliable map I was able to purchase from the Government was, I believe, mostly compiled from one originally made by the Duff Company, to whom in all things relating to the opening up and development of Kelantan the present white population of the state owe many thanks, a fact which many of them seem to ignore or forget.

Apart from the limestones, quartzites, shales, and conglomerates already mentioned, one finds clays, slates, schists, sandstones, and granites, the last being predominant.

MINING OPERATIONS.—In spite of the difficulties of prospecting, the Chinese appear to have been through the country long ago; and at the only two places where lode-mining is known to have been attempted—near the Sokor river and at Kundor, near Pulai—the surface had already been prospected and sluiced for gold; but the lodes there had been allowed to remain otherwise undisturbed. In the neighbouring states of Pahang and Trengganu the weathered outcrops of such lodes as have been found to exist there had been worked, without exception, by Chinese or Siamese in the years long gone by; and many hold that the most successful method of lode-prospecting is to follow the old native workings.

As the population of Kelantan is mostly confined to narrow strips along the banks of the main rivers, and as the Malay, as a rule, is either afraid or disinclined to go far into the jungle, very little information is to be obtained from them with regard to anything in the country except in close proximity to their homes; but it is possible that, when the country has been opened up by the advent of the railway and the population has become denser, further old workings will be found which will lead to the opening up and development of large ore-bodies lying in country now given over to tigers, elephants, and panthers.

The Duff Company spent a large amount of money in prospecting and in dredging the river bottoms; but none of its mining ventures was attended with lasting success. It would appear that the dredges gave variable results, rich periods of work being much interspersed with very lean ones; the four dredges at work seem to have lacked efficient supervision from headquarters, and the gold returns to have been most erratic.

Map of the State of Kelantan.

The Author's Journeys.—A great deal of tunnelling and shaft-sinking was done by the Duff Company near the source of the Sokor river, on what are often referred to as the galena mines. Operations were carried on there until 1907. While awaiting the fulfilment of certain business negotiations with regard to a concession of two hundred square miles, which was the primary cause of my presence in Kelantan, I arranged a visit to these old mines. As the Sokor river enters the Kelantan river about midway between Tanah Merah and Kuala Lebir, I sent forward the leader of my party to engage men and boats and meet

me at the mouth of the river. As I was on the point of leaving Kota Bharu to join the expedition, word was sent down that the men who had been engaged were afraid to proceed when they found that the expedition was to traverse the "poison" belt—the bad man's country—where it is said that one can arrange for the death of an enemy for half-a-dollar and where most of the native potions and poisons are compounded. I happened to mention the matter to the Chief Police Officer, who sent a party of native police with me, and we proceeded upstream, engaged new men and boats, and started shortly after daybreak from the mouth of the river. We took the Duff Company's old route to the mine, poling up the Sokor river and then walking six miles overland. Estimates of the river distance were very variable, and, as before stated, the maps available very inaccurate. However, our boat journey occupied a good long day and a half; and, as the river at the time was fairly high, good progress was made until the middle of the first day. After that the river became a series of rapids, shallows, sandbars, and deep pools, which meant wading in the water a great part of the time, digging passages through the shallows, and all hands hauling the five prahus which formed our means of transport. It was no uncommon thing to find the bows of one's prahu lying in ankle-deep water, while the stern projected over the edge of a steep bank of granite sand in a depth of over fifteen feet of water. We reached our river destination during the second day and pitched camp; and our six-miles tramp next day brought us to the deceased mining camp. This tramp was over the old wagon road of the Duff Company; and, although then devoid of bridges and much overgrown with jungle, the track was in otherwise excellent condition. As far as jungle growth was concerned, our way had been made easy by an adult and a baby elephant who had evidently traversed nearly the whole of the road the day before and whose beds of the previous night we passed on our journey. My natives were interested, but not afraid, when we met with the elephant tracks. It was not until we crossed the spoor of a sladang (wild buffalo) that I had difficulty with my bearers, for the sladang is regarded as the most dangerous animal in the Peninsula. It is a matter of common report in the East that he who goes out to seek sladang must keep a watch to the rear as well as to the front, the sladang becoming the hunter instead of the hunted if sufficient care is not exercised.

Various tunnels into the hillsides were noted; but all that remained of the former main engine shaft was a jungle-covered hole and some rotting timber. History relates that after the mine had been closed, and even before the last of the stores had been carried to the river bank, the Malay natives had swarmed in and stolen every bolt and piece of iron from the headgear, even going part way down the shaft in search of bolts, etc.

No galena could be seen on any of the old dumps we were able to find; but records show that a parcel of about 57 tons was bagged and sent to the smelters just prior to the closure of the mine. The dumps examined showed that the bulk of the material mined must have been of a pyritic nature, and the records also show that 80 tons of such ore was dispatched about the same time as the galena. One of the old assay books discovered at Kuala Lebir showed the large amount of exploratory work which had been carried out, and that as the work proceeded the ground was regularly sampled and the results carefully tabulated. Most of the assays from the "galena deposit" show gold and silver values only; and some of these are of considerable richness. For example, the following values are taken from a width of ore varying from two to five feet: Gold 64·8 dwt., silver 1·6 oz.; gold 38·4 dwt., silver 2·3 oz.; gold 44·0 dwt., silver 4·0 oz. The following assays are recorded from "Manson's deposit": Gold 1·6 dwt., silver 4·9 oz., lead 12·5%; gold 2·8 dwt., silver 8·2 oz., lead 36·0%; gold 1·6 dwt., silver 3·3 oz., and lead 14·5%. The records also mention the diamond-drilling of vertical holes in the slates; but encouraging results do not appear to have been obtained. It would seem that the whole mining proposition at this place was killed by bad transport arrangements. A road from the Kelantan river to the Sokor mines, say, twenty miles in length, and then extended to the Pergau river, say, another five miles, would not only have served the mines then being worked, but would have opened up a most promising belt of country extending up to the Tomo (Siam) alluvial goldfield. In spite of the fact that labour was considerably cheaper in 1907 than it is to-day, it cost the Duff Company approximately £80 to bring a moderate-sized boiler from the mine; and the smaller items of machinery, weighing from 8 cwt. to 1 ton, were contracted for at a rate of about 3s. 10d. per cwt. The slowness of river transport may be gathered from the manager's statement that loaded prahus which had left the head of the river on the Tuesday could not be expected back before the following Saturday.

My return down stream in our lightly-laden

prahus and with the channels dug on the up journey still available was comparatively rapid.

Upon another occasion I travelled on foot from the Kelantan to the Bertang river, a tributary of the Sokor, and found native mercury in the bed of the stream for quite a considerable distance in the Duff Concession. Later on I took an expedition up the Sokor river, where I was informed that quicksilver could also be found, for, if the metal could be found in both rivers, it meant the probability of an extensive mercury-bearing belt. On this occasion we travelled up the Sokor to our old river camp, but, the river being lower this time, we were forced to leave our largest prahu part way up and finish our river journey in relays. Arrived at our destination we set out for the spot where our guide said he had found mercury before; but none was to be found on this occasion, and it turned out that our guide had not been upstream to the supposed spot for at least eighteen years. He had with him a specimen of gålena which he said he had found in a hole 8 ft. deep some twenty-two years before, and was much incensed because I would not go with him to search for that 8 ft. hole which, according to the location given by him, must have been within the area afterward prospected and worked by the Duff Company.

Our last night at the Sokor was somewhat unpleasant, as the river began to rise and, having left our largest prahu some distance down stream, we had not sufficient carrying capacity for the whole of our men, kit, and provisions. We were therefore faced by a raging torrent on one side and a jungle infested with leeches and wild beasts on the other, and of these the leeches were the worse, while the rain was coming down as only it can come down in the tropics. However, we managed to hang on until daylight, when we built some bamboo rafts and floated away on the tide of the flooded river.

I made expeditions to other places where tin was supposed to exist within easy reach, but found, as a rule, only iron sands.

Just before the wet season was expected I set out with my guide in two prahu-dowds for the upper waters of the Galas in search of that Golconda of Kelantan, the Kundor mines. A prahu-dowd is the largest form of native up-river boat; ours were about 50 ft. long and 5 ft. wide, having a covered-in living-room in the centre about 14 ft. long but only $4\frac{1}{2}$ ft. high. Each was poled along by four Malays under the direction of the helmsman, who steered by means of a long oar lashed to the stern.

Prior to setting out on this expedition I went to Kota Bharu and asked the British Adviser whether any of the land up the Galas river had been granted for mining purposes. The British Adviser referred me to the District Officer up-river at Kuala Krai. An inquiry from the said District Officer received a reply that there were no papers in his office which showed that any of the land had been alienated for mining and that therefore all the land was open to me; but he advised me to take out a prospecting licence before starting. A Kelantan prospecting licence states clearly the location of the area to be prospected; but, as neither my guide

A Road at Kota Bharu

nor I knew the exact location of the Kundor mine, but were to be met by local men sixty miles above Kuala Krai who were to take us to the spot, it was impossible for me to take out a prospecting licence at that moment; but I agreed to send a special messenger down for a licence as soon as I had located the old workings. This I did, applying for an area of 4,000 acres. I was away with my expedition for a month, living and travelling in my prahu, and after having done some track-making and opening-up of the prospect, was compelled to return on account of the serious illness of my guide and also by the rapidly-approaching rainy season. On my arrival at Kuala Krai the District Officer informed me that after my departure the British Adviser had sent him some papers which tended to show that the

land for which I had applied had already been alienated and was not therefore available. My protest to the British Adviser brought the absurd reply that he was inclined to think that if I had obtained my prospecting rights before proceeding upstream from Kuala Lebir I should have avoided this loss of time and money.

My river journey of seventy miles from Kuala Krai to Pulai took sixteen days; and I had not travelled very far above the junction of the Pergau river before the difficulties of transport became apparent. The river had become impassable for anything but light-draught prahus; we encountered rapid after rapid, up which our prahus often had to be dragged with long ropes; and through many rocky and sandy places we had to dig channels for our craft.

The Chinese town of Pulai, which is known to have existed for over a hundred years, is a great contrast to the Malay kampongs with their jungle-constructed houses. In Pulai the houses are two and three storeys high, the thick walls being constructed of a lime concrete of rounded pebbles and river sand. The natives mostly make their living from alluvial mining; but the Kelantan Government gets very little in the way of taxation from the district, as most of the traffic is by foot over the border into Pahang. Formerly a Malay police inspector and several police were stationed at Pulai to collect dues; but they are reported to have spent most of their time in gambling, and when the barracks were being burned to the ground the Chinese residents say that the Malay police prevented them from attempting to extinguish the flames or salve the books and records, all of which were lost.

The Pulai Chinese are the remnant of a much larger population of the past. Some hundred years ago the ruling Rajah of Kelantan made over to his son the taxes on rice; these the Pulai Chinese refused to pay and, when the Rajah's son came to enforce the payment, they killed him. In revenge for this a punitive expedition was sent, with the result that most of the Chinese were killed, the Galas river ran red with blood, and was afterwards blocked by rotting corpses. Only a few of the residents escaped by hiding in the jungle; and those are said to be the ancestors of the present population. I had a number of Chinese working for me at Kundor and, although only one or two of them could speak Malay, we soon came to an excellent understanding. I found them a hardworking, jolly, capable crowd, and eight of them worked my prahus down-stream for me as far as Kuala Lebir, that being much farther than they had ever been away from Pulai before.

Kundor proved to be about eight miles down river from Pulai; and an inspection showed that much alluvial gold must have been won there. The Chinese had constructed several miles of water-races, and in some cases they had cut these for a depth of 15 or 20 ft. through the granite. The property had been worked by a Dutchman in more recent years, and he had done a fair amount of tunnelling and shaft-sinking before his death. The reputedly richest portion of the property was at the junction of the granite and the slates, and I made arrangements with the Pulai Chinese for the opening up and repair of the old workings at the conclusion of the approaching wet season, only to find on my return to Kuala Krai that the ground was not available.

Coming down stream I stopped, inspected, and sampled several quartz outcrops of good appearance with a view to a return visit at a later date.

The occurrence of a tin lode was rumoured on the border of Kelantan and Trengganu, and it is possible that such lode may exist, for in the state of Trengganu the privately-owned Bundi tin mine is reported to have given good returns to its owner. The neighbouring state of Pahang gives the only other example of lode tin mining on a large scale in Malaya. In Pahang the Chinese and Siamese are known to have worked the soft outcrops of at least forty lodes. These lodes are in the slates near the junction with the granite, into which they sometimes penetrate. In Trengganu wolfram veins are found in formations of quartzite, schist, and shale overlain by clays. The veins are worked only down to old water level, below which the sulphides of iron, copper, and arsenic occur. The ore, as sent away, contains 70% of tungstic acid. Wolfram found in the Federated Malay States is associated with tin; in Trengganu wolfram is found alone.

Alluvial tin is found in limited quantities in Pahang, Trengganu, and Kelantan; and it is a surprising fact that so much alluvial tin, shed from the range which forms the backbone of the peninsula, should, so far, have been found on the western side and so little on the eastern side of the range. When it is remembered that the Malay States have produced tin to the value of £180,000,000, the small proportion obtained from the eastern states gives much food for thought.

RUBBER INDUSTRY.—One cannot remain long in Kelantan without being impressed with the value of the land as a rubber producer.

There is plenty of virgin jungle, good loamy soil with good depth of humus, and light rolling country with easy drainage; there is no great variation in temperature to affect the flow of latex, and a reliable and generally well-distributed rainfall is assured. Growers state that rubber trees come into bearing six months earlier in Kelantan than in the western Malay States. At the conclusion of my mineral excursions I explored a considerable area of the country, finally demarcating some ten thousand acres for rubber planting. This involved living among the up-river Malays for a considerable period and the cutting of some thirty miles of tracks and survey lines.

In clearing the virgin jungle, Malays are generally employed, and carry out the work most satisfactorily. The jungle, though dense, does not carry a large number of trees of large girth to the acre; most of the jungle is "secondary." The Malays say that fifty years ago the whole country was devastated by a tornado and every tree was rased to the ground; that fire then got into the fallen jungle; and that Kelantan was on fire from end to end, men and animals being driven into the rivers by the heat and smoke. If this statement is true—and some of the older men say they can remember the conflagration—the comparative sparsity of big timber can be easily understood.

The planting of the rubber trees and all subsequent work is best performed by Tamils, Chinese, or Javanese, all of whom must be imported from their native countries.

Rubber trees should give at least 200 pounds of latex per acre for the first year of tapping, increasing yearly by 50 pounds per acre. A rubber estate should show a profit on its second year of tapping. Of course the crop of latex will vary with the quality of the ground and the care bestowed upon the estate. At the Pergau estate in Kelantan the average output is about 415 lb. of latex per acre tapped; but some of the best land gives 660 lb. per acre. Costs of production will vary with location, nature of land, and efficiency of management. Owing to the absence of transport facilities in Kelantan, costs may be expected to be higher for the time being than those in the western states, where some of the best estates have been able to produce at as low a cost as 23, 24, and 25 cents per lb., and the average of the best is 35 cents or about $9\frac{4}{5}$ pence per pound. The costs on many of the estates are, of course, much higher than these. In Kelantan the lowest costs are obtained at the Bagan Estate, where rubber is produced at an all-in expenditure of 29 cents per pound. Owing to the situation of the estate and the ability of the management, Bagan is able to use Malay labour in all branches of the estate work, proving thereby an exception to general Malayan enterprises. The Taku Estate of the Duff Development Company is producing rubber at the very satisfactory cost of 34 cents per pound.

Other Industries.—For their own immediate consumption the Kelantanese grow a fair quantity of tobacco, and an increase in this industry might be encouraged with advantage by working somewhat on the lines of the Borneo practice. The tobacco grown is not of high grade, but there is a ready sale for it among the natives of the surrounding countries. In Borneo the landowner lays out $1\frac{1}{2}$ acre for each native to cultivate and supplies him with tobacco seed. The native raises the tobacco and gathers the leaf, which is bought from him by the landowner in its green condition at twenty dollars per picul ($133\frac{1}{3}$ lb.). As a Malay should produce fifteen piculs from his acre and a half of properly cultivated land, he should be able to make three hundred dollars for eight months' work on his patch. The cost of shredding, drying, fermenting, and curing should amount to a further expenditure of forty-five to fifty dollars per picul, and the

A Kelantan Sea Beach

finished article can be sold for about one hundred and twenty dollars per picul.

Although some of the world's finest copra has been exported from Kelantan, coconut growing on a large scale has not been very successful up to the present time. The excellent sun-dried copra which the natives produce comes from their small kampongs where the trees thrive on the refuse, animal manure, and other filth which usually surrounds native habitations.

FINANCE.—The last annual report of the Kelantan Government showed the revenue collected to have amounted to £112,000, including land revenue £21,000, levy on imports and exports £31,700, and profit from the sale of chandu (opium) £29,000. Half of the export revenue of £17,000 was obtained from rubber, 10% from betel nuts, 17% from copra, and 9% from cattle. Heavy export duties have often been placed on produce in order to prevent the natives from bringing themselves into a condition of semi-starvation. Chinese traders used to travel throughout the country, reaching even the remotest kampongs, buying up cattle, fowls, ducks, rice, dried fish, &c. The Malay, having but little insight into external trading, was disposing of all his animals and birds, leaving himself no means of replenishing his stocks; he even sold his agricultural cattle and then had no means of cultivating his rice. Owing to the high export duties imposed, the exports of livestock are now mainly composed of pigs, pork being forbidden as an article of diet for the Malay. Rubber stood at the top of the list of exports, being two-thirds of the total value of £425,000. The imports were valued at £300,000.

CLIMATE.—The highest temperature recorded was that of 98° F. in Kuala Lebir in 1914, and the lowest was 62° in 1913, also in Kuala Lebir. At the sea-coast the mean maximum and minimum temperatures may be taken at 90° and 71°, while 60 miles inland they may be taken at 96° and 64°. The mean temperature throughout Kelantan is about 79° or 80°. In Kuala Lebir the annual rainfall taken over a number of years shows a variation between 74 and 136 inches; records in Kota Bharu show 95 to 165 inches with a maximum fall of 13·43 inches in 24 hours.

The wet season is distributed over November, December, and January when the relative humidity rises to a maximum of 90%. The wet season is immediately followed by the dry months of February, March, and April, in which the mean relative humidity is about 80%.

Living in the jungle, one is impressed with its stillness and quietude. No birds are to be seen except in the topmost branches of the highest trees. Occasionally a flock of monkeys is heard dashing away overhead, and in the early morning one may sometimes disturb a deer or wild pig. The air is still and breathless; there is never any wind. The morning often shows the tracks of elephants, tigers, and panthers which have not been far distant; but it is seldom that any of these animals is seen, and very few residents of the Malay States have been close enough to get a shot at a tiger. For a native to be attacked by a tiger on the east coast is unknown; but on one of the estates about 35 miles from Kuala Lumpur the toll of natives killed by tigers during the past twelve years has been quite a heavy one. This is attributed to the closer settlement of the district having driven the natural food to the tiger —the pig—away. Unlike the remainder of the Malay States, Kelantan is entirely free from crocodiles and bathing is therefore possible in all waters. Elephant hunts occasionally take place, and I visited one of the stockades into which they are driven, then in course of construction near the source of the Rek river. The animals are tamed and trained within a few weeks of their capture.

CONCLUSION.—In my exploration and in my various excursions I received much assistance from the officers of the Duff Development Company, the Chief Police Officer, the Government Survey Department, and District Officer Monk. Had it not been for the kindly offices of these gentlemen my way would have been much harder and my operations delayed; but I was deeply disappointed by the short-sighted policy of the highest Government officials who, as soon as I made application for rubber lands, gave notice of the imposition of higher rates and rents. An appeal against such imposition was upheld when placed before the Governor of the Straits Settlements; but restrictions introduced with regard to the employment of labour and the growing of food-stuffs made it so evident that enterprise from outside was not welcome that it was decided to withdraw entirely from a venture which would have included the opening up of 10,000 acres of agricultural land at an estimated expenditure of over £400,000 in a country sadly in need of development and of the introduction of capital.

[In connection with the foregoing article, readers may be reminded that the neighbouring State of Trengganu was described by Mr. Henry Brelick in the MAGAZINE for November, 1915.—EDITOR.]

DOLCOATH'S FUTURE.

We print herewith the reports by Mr. R. Arthur Thomas, managing director of Dolcoath, and by Messrs. Bewick, Moreing & Co. on the proposed scheme for exploring the northern ground in depth for tin.

FOR some time it has been known that the ore supply in depth at Dolcoath has been failing, and that the engineers are in favour of exploration laterally. The concrete proposals are now published, and the main points are given herewith. Briefly the proposal is to run a cross-cut at depth northward from the Williams vertical shaft in order to test the Roskear lodes at points below the deepest level of the old workings. The Roskear lodes were profitably worked for copper until forty years ago. At that time the copper gave out and tin put in appearance. The problem now is to test the lodes for tin at depth. It is expected that the cross-cut will also reveal information relating to south-westerly continuations of lodes worked at East Pool and South Crofty.

Mr. R. Arthur Thomas's Report.

It has not been possible for some time past to record any satisfactory results from the operations at Dolcoath, and it has been found necessary to greatly curtail the scale of working pending the consideration and determination of the future policy. In June last the bottom workings were abandoned and the pumping plant and sundry appliances have been successfully withdrawn from the 550 fm. level.

Having regard to the improbability of any immediate profitable developments on the main Dolcoath series of lodes sufficient to retrieve the position, new work must be embarked upon and capital provided therefor to restore the mine to its former importance as a profit-earning undertaking. This result will, I confidently anticipate, be realized if the following scheme of development can be carried out, that is, to drive a cross-cut from the Williams shaft north at the 338 fm. level to intersect the various lodes shown in the accompanying plan, and which have not been worked by this or any other company to such a depth. The plan shows the Dolcoath lode series and the projected position of the various lodes to the north, which will be intersected by the proposed cross-cut. The reasons for my unhesitatingly recommending the driving of this cross-cut, and my belief that in so doing the company will again become a profitable as well as large undertaking, are as follows:

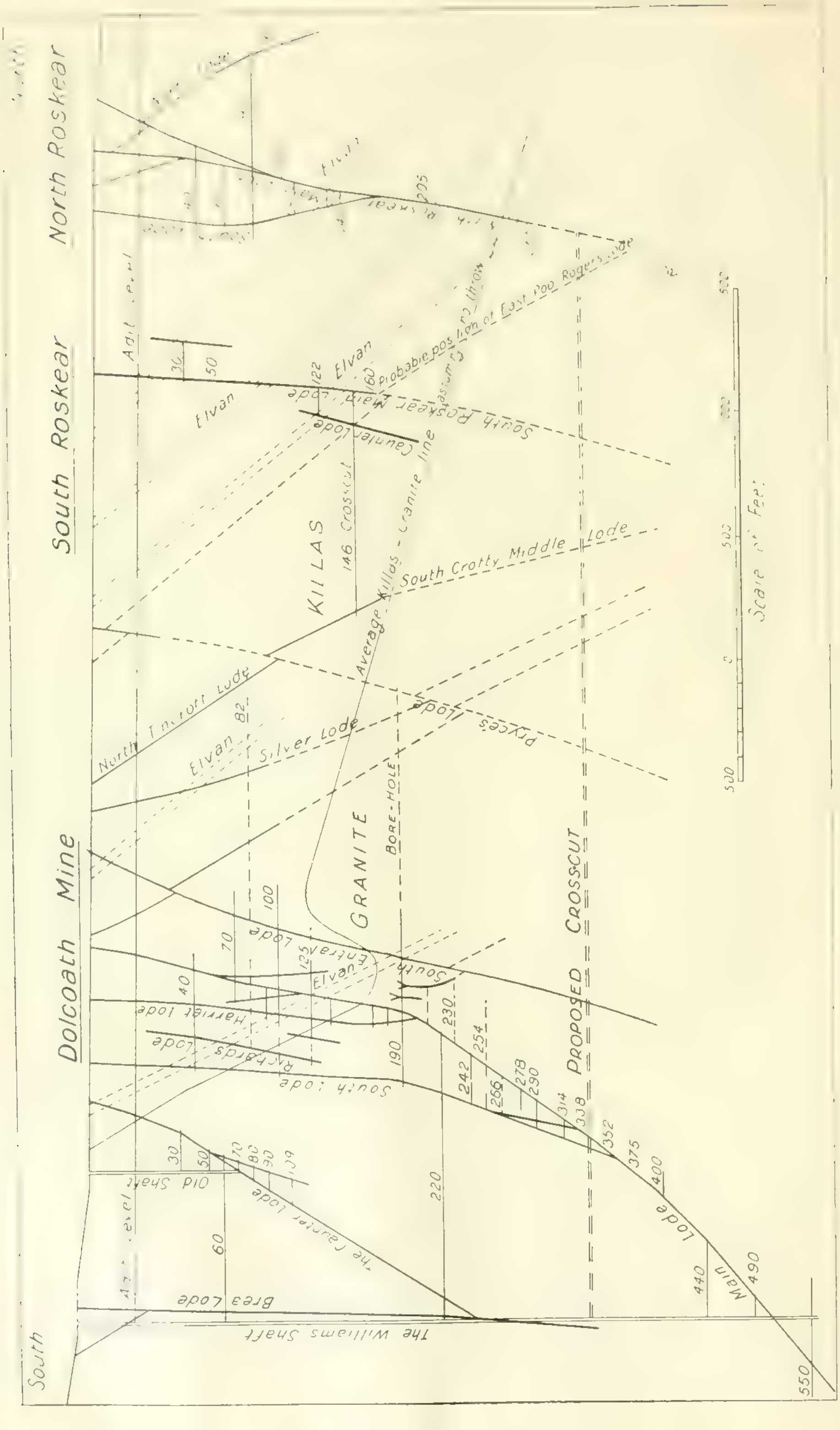
(1) Before the South and North Roskears, as well as the East Pool (Rogers) lode, lying between these two lodes, would be intersected, the important Tincroft and Crofty series of lodes would be met with, and also the various other lodes, of possibly less importance (forming a part of the series referred to), at less than half the distance of the total length of the cross-cut, which is estimated to be 4,420 ft.

(2) The mines to the north of Dolcoath, namely, South Roskear, North Roskear, and the Setons, slightly to the west, were large producers of copper in the killas, as was also Dolcoath in the approximately parallel lode series in the killas overlying the granite in which the Dolcoath main series of lodes have been so remarkably consistent producers of tin to a far greater depth than has been reached elsewhere in the country. None of the lodes in the northern areas referred to has been explored in the granite.

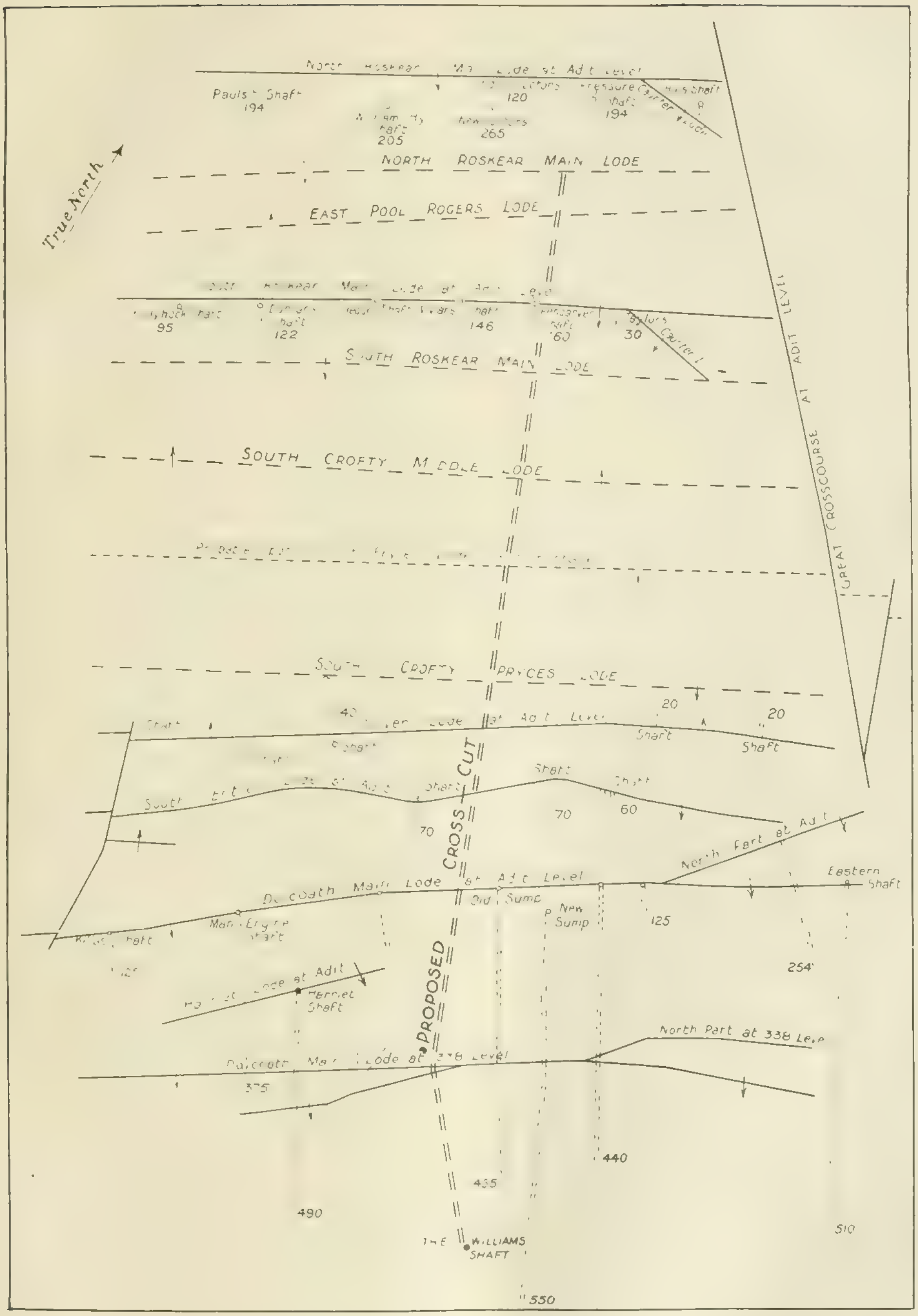
(3) Dolcoath mine produced copper to the value of £2,328,435, and subsequently in the granite tin realizing £6,842,351 by working to a depth of 550 fm. from surface. The South and North Roskears produced copper to the value of £1,024,623 and in the latter working tin to the value of £121,171. The adjoining properties, the Setons, also produced copper to the value of more than £1,125,000 and tin to the value of over £500,000. The foregoing figures in themselves without giving a detailed history of the working of these properties show this area to be highly mineralized, and it must be remembered that the above returns were made mainly when copper and tin were at a very low price.

(4) The geological conditions in these northern areas being similar to those at Dolcoath, the fact that there was a distinct change in the country rock in the bottom of the Roskears at the 300 fm. level, and that these mines at the time of their suspension became tin producers, coupled with the relative proportions of tin and copper produced (particularly at Dolcoath) on its main series of lodes provide prima facie evidence that the expectations for discovering tin by the proposed cross-cut in the granite are well founded.

(5) The recent discoveries in South Crofty, which adjoins the eastern portion of this mine, and the East Pool and Agar mines (particu-



TRANSVERSE SECTION FROM DOLCOATH TO THE ROSKEAR MINES.
The figures represent depths in fathoms below Adit Level.



Plan of Dolcoath and Roskear Lodes

Lodes at Adit Level marked in full lines; lodes at depth of proposed Cross-cut in broken lines.

larly the phenomenally rich Rogers lode) have undoubtedly demonstrated that the northern series of lodes are highly productive for tin in the granite and are distinctly confirmatory of the view held that the group of unexplored north lodes will become, by development in the granite, tin producers and on a considerable scale; moreover, it may be said that there is a general concurrence of opinion among mining men, supported by eminent geologists, in this anticipation.

(6) Dolcoath and the Roskears are divided from the eastern group of mines, that is, South Crofty, Tincroft, and East Pool and Agar by the great cross-course, and all the mines bounding this to the west have been very large producers of copper and tin; and it may be said that the eastern mines have been very successfully worked for a great mumber of years in the granite.

(7) The 338 fm. level from which the cross-cut would be driven has been chosen because, among other reasons, it will intersect the lodes above referred to and give high backs, and at the most favourable point below the line of the killas-granite contact, so that it seems highly probable that large bodies of ore will be available for working before the cross-cut reaches the Roskear mines.

(8) The Williams shaft is a very valuable asset in this scheme of development, as it is of ample capacity for a large output, for such pumping plant and mechanical haulage as may be necessary, and is equipped with a first-class winding-engine and general mechanical and electrical appliances, providing most excellent opportunities for the concentration and rapid progression of all operations. There is no engineering difficulty in returning through this shaft the ores from the lodes that will be cut by the proposed cross-cut. The use of the Williams shaft will render it unnecessary to sink a new shaft on the northern properties, at all events for a long time ahead, if at all.

To carry out this projected work will entail an estimated expenditure of £120,000, in which estimate is included the provision for a pumping plant of ample capacity to meet the probable requirements by utilizing the pumps removed from the bottom of the Williams shaft, and for preliminary development in the lodes to be intersected by the cross-cut.

Extracts from Bewick, Moreing & Co.'s Report.

We have examined the scheme as drafted by Mr. R. Arthur Thomas, covering the exploration and working of the northern ground, including the North and South Roskear and other lode channels, as well as the probable continuation of the Rogers and other northern lodes now being worked or explored in the eastern end of the Camborne-Redruth belt. The prospects of this scheme, its feasibility, the time necessary for its completion, and the capital required are factors of importance.

We have, for several years, given close attention to the geological features of this field relating to its ore-bodies, and have prepared very complete plans and sections covering the area from Dolcoath on the west to Tolgus on the east. From these we have made the plan and section accompanying this report, in which the various known lode channels and probable continuations of lode channels are shown diagrammatically, the former by continuous heavy lines and the latter dotted. These may be divided into two groups, the one of large, well-defined productive ore channels, the other of minor channels which may develop satisfactorily in the granite. There is also the further possibility of locating unknown lodes which do not appear at the surface.

The first group includes the following lode channels, taken in the order in which they will probably be met by the proposed cross-cut: (1)—Price's; (2)—Crofty Middle; (3)—South Roskear; (4)—Rogers; (5)—North Roskear.

The second group, which for the present seems to be of minor importance, includes among others the following: (1)—Dolcoath South Entral and other lodes worked to the north of the Dolcoath main lode; (2)—Minor lodes which may continue west from South Crofty; (3)—Sundry minor lodes, formerly worked in the Roskear mines.

It has been clearly established that the Great Cross-course on the eastern boundary of Dolcoath does not cut off the known eastern lode channels, but merely displaces them to the north in the western ground, and it is therefore a reasonable inference that any strong eastern lode channel which lives to the cross-course is likely to continue west of it. Quite apart from that, however, this scheme finds justification by reason of the known lode channels in the western ground, which in the past have been so productive in copper, and have not entered the zone which experience and investigation indicate as likely to be more productive in tin. Reviewing the figures available on the Camborne-Redruth district up to the year 1919, it stands out very significantly that the leading tin producers are those mines which in the early days produced much copper, and then sank to greater depth, penetrating the granite. The

following tabulation of output of tin and copper at Dolcoath, East Pool, South and North Roskear points to the prospects of the two latter as tin producers in the granite:

	Copper Ore	Black Tin	Depth of Granite	Deepest Working
	£	£	Fm.	Fm.
Dolcoath	2,328,435	6,785,998	125 to 200	550
East Pool and Agar	457,322	2,700,736	135 to 212	340
South Roskear	217,993	15,160	? 255	170
North Roskear	806,630	106,011	? 280	280

The remarkable richness of the belt of country running from Dolcoath on the south to old Wheal Seton on the north is shown by the following figures giving the returns to 1919, which further emphasize the possible potentialities for tin in the ground between Dolcoath and the Setons, which so far is practically unexplored in depth:

	Copper	Tin	Total
	£	£	£
Dolcoath	2,328,435	6,785,998	9,114,433
South Roskear	217,993	15,160	233,153
North Roskear	806,630	106,001	912,631
Wheal Seton	535,286	71,664	606,950
West Seton	719,341	454,836	1,174,177
	4,607,685	7,433,669	12,041,344

The South and North Roskear mines have produced over a million pounds' worth of copper ores. Neither of them has, as yet, been explored in the granite, and both, in their deeper levels, have been tin producers. The early history of these two mines is obscure, and it is difficult to give exact figures covering their output and workings, but the information herein compiled is believed to be on the conservative side.

The South Roskear has been worked for a length of about 4,000 ft. The two main shafts (some 2,000 ft. apart) are Wheal Chance Engine Shaft (Gregory's Shaft) in the western section, 184 fm. below adit, or 214 fm. from surface, and the Pendarves Shaft in the eastern section, about 180 fm. below adit, or 210 fm. from surface. Old reports refer to six distinct lodes as having been located, but the main workings were confined to the South Roskear main lode, which, near the surface, is almost vertical, but from the adit level dips steeply to the south. The greater portion of the large output of copper was obtained from the adit down to the 150 fm. level, and tin began to appear in quantity at the 112 fm. level at Dunkins Shaft. The eastern workings are not connected with the western below the 80 fm. level, and the water in the former was handled by flat rods worked by the winding engine, and then passed westward along the 80 fm. level to the Wheal Chance Engine Shaft, where it was pumped by a 70 in. engine. The maximum quantity was reported as 156 g.p.m., and it was considered that the 70 in. engine was in 1876 ample for the requirements then and in the future. The mine closed down in 1881, the contributing causes being as follows: the large copper bodies were largely exhausted and the price of that metal was seriously declining; development was not sufficiently far ahead to open up the deeper tin ground, and the price of tin had declined so seriously as to discourage any attempt to go deeper.

The North Roskear Sett was over a mile long and the lode was worked for a length of over 4,000 ft., the chief workings being on the North Roskear main lode. The two main shafts (some 1,700 ft. apart) were the New Doctor's Shaft on the east, 270 fm. below adit or 300 fm. below surface, and Pearce's Shaft on the western end, 220 fm. from adit or 250 fm. from surface. Paull's Shaft, Pressure Shaft, and Prince William Henry Shaft were also sunk, all over 200 fm., so that the mine was opened up by five deep shafts as well as several to the region of 100 fathoms. Latterly the workings were confined chiefly to Pearce's and New Doctor's shafts. In 1871 Captain Josiah Thomas advocated the sinking of the latter shaft to cut the granite, which he considered was at no great depth below the bottom workings, and there he expected that a lasting and profitable tin mine would be opened up. Here, however, as in the case of the South Roskear, adverse influences became so felt that the mine was closed down. The large copper stopes had become exhausted, the prices of tin and copper seriously declined, and, although in this case the tin zone had been entered, particularly in the deeper workings at New Doctor's Shaft, still the development in that zone was quite insufficient to open up sufficient tin reserves, and therefore in 1874 operations ceased. It is worthy of note that in the bottom portion of the shaft a distinct change was reported in the nature of the country, felspar, quartz, and much mica appearing.

Having outlined the results of the operations on the two lode channels, which have been worked, those which may be expected to continue through the country to be explored by the proposed cross-cut are now referred to in the order in which they are likely to be met with in cross-cutting.

Pryce's lode channel lives from East Pool through Tincroft and well to the west in Crofty, but so far has not been worked up to the Great Cross-course. On account of its strength and persistence it seems probable that it will live in the western ground. It has produced large

quantities of copper and tin in the above-mentioned mine. In Tincroft it has, until recently, been responsible for more than half the returns, and was worked for a length of 2,400 ft.; it is considered there that it will make junction with the South lode at 257 fm. with good prospects of enrichment.

Crofty middle lode is the continuation of the North Tincroft lode after being thrown northward by Pryce's lode, and has been very extensively worked in South Crofty. Like Pryce's it has not been driven west to the Great Cross-course, there being apparently a poor zone affecting all lodes to the immediate east of the cross course. Considering, however, the great richness of the Dolcoath and the Roskears on the west, these lodes may improve in tin contents in that zone. The North Entral lode of Dolcoath, which coincides with the North Tincroft lode, was intersected at the 80 fm. level, close to the northern boundary, and after being faulted by Pryce's lode was cut by the 146 fm. cross-cut south from South Roskear in the killas.

The Rogers lode, which in East Pool has been opened up in the granite with such excellent results, was of little account in the killas. To the west it meets Reeves lode (the Great Caunter), and is faulted by it in the eastern section of South Crofty. There it is thrown to the north, its continuation being known as the Longclose lode. Unfortunately the 245 fm. bore-hole in the western section of South Crofty (east of the cross course) entered the killas before cutting the lode channel and was consequently too shallow to enter the tin zone. This lode dips to the north, whereas the South and North Roskear lodes both dip to the south, and its continuation will probably be, as shown in the accompanying section, in the neighbourhood of the South Roskear lode channel, and at the depth of the cross-cut may be expected some distance to the north of the South Roskear main lode.

The following table gives the approximate distance at which the above lode channels are likely to be cut, these being determined on the normal dips and strikes, any deviation from which will correspondingly affect the positions:

LENGTH OF CROSS-CUT.

From Williams Shaft to South Entral Lode Channel about	1,300 ft.
" " " Pryce's " " "	2,400 ft.
" " " Crofty Middle " " "	3,200 ft.
" " " South Roskear " " "	3,600 ft.
" " " Rogers " " "	4,[illegible]00 ft.
" " " North Roskear " " "	4,500 ft.

The line of section on which the above measurements are made runs from Williams Shaft to a point between New Doctor's Shaft and Pressure Shaft at North Roskear.

The depth of the granite slope is known in South Crofty and New Cook's Kitchen setts, and in North Crofty (by bore-holes), and in Dolcoath the granite has been located by the 190 fm. north cross-cut, and the bore-hole from its northern end, which are both in granite, covering together a distance of 1,430 ft. north of the main lode. The position has also been determined on the main lode. On the other hand, in South Roskear the 146 fm. south cross-cut was extended nearly 300 ft. south (on the section line) and was in killas. Therefore the surface of the granite is very closely determined as lying between the end of the northern cross-cut, at the 190 fm. level from Dolcoath, and the end of the southern cross-cut from the 146 fm. level from South Roskear. South-dipping lodes generally throw up the granite floor, and north-dipping lodes depress it. It appears that in the present case the former tendency will be the more marked.

Variations in the dip of the granite surface may occur, and for that and other reasons the proposed cross-cut should be driven at a depth considerably below the granite floor, which is considered to be very close below the 255 fm. level at North Roskear. The depth proposed, 338 fm. below adit at Williams Shaft, provides reasonably for this contingency and allows for good backs on the various lode channels intersected. On the normal dip of the granite surface and lodes, as shown in the accompanying section, there would be on the South Roskear lode about 500 ft. of backs, and on the North Roskear about 300 ft. of backs.

On both the South and North Roskear lodes there were very considerable lengths of rich copper lodes, and the best line for the cross-cut would be underneath the richest portions of the old copper workings, which allows considerable latitude in location. The position chosen in the neighbourhood of Doctor's Shaft locates the cross-cut favourably for exploration of the probable tin zone in the different lode channels. The cross-cut would therefore explore the ground from Williams Shaft, Dolcoath, to Doctor's Shaft at North Roskear, following practically a straight line connecting these two points with, however, a slight deviation to allow the cross-cut to avoid old workings on the Dolcoath South and Main lodes, which should be cut in a distance of about 700 ft. from Williams Shaft. The location of this point is of such importance as to warrant, before commencing the cross-cut, a check survey from Williams Shaft to the workings to the near east of Harriett Shaft.

GOLD MINING IN CHILE.

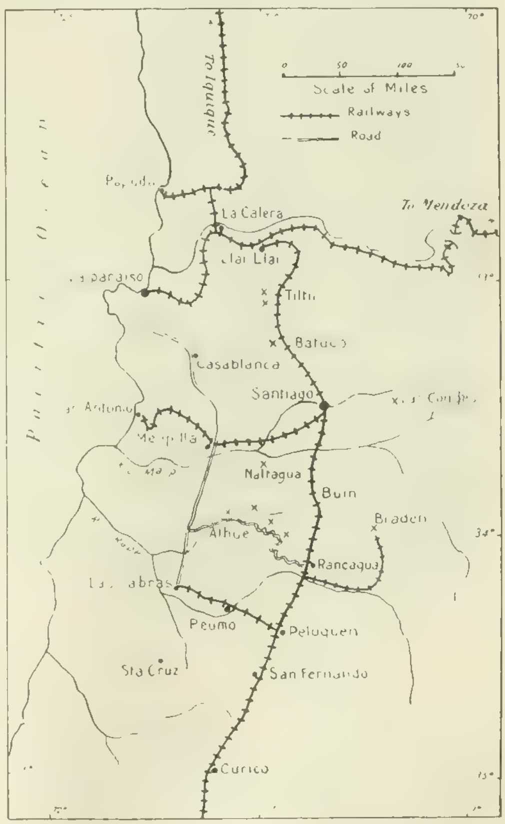
By LAURENCE PITBLADO, M.Inst.M.M.

The Author writes of a neglected industry, the mining of low-grade deposits, which can be done under most favourable climatic and economic conditions.

HOLDING the third place among gold-producing countries up to the 18th century, Chile has now descended to practically the lowest on the list. Judging by its status as a metal-producing country, one would naturally have expected this condition of things to be reversed. It cannot be said that the Mining Laws of the country are against the industry, as they are the most simple and indulgent known to me, giving a right to mine over every hectare of ground taken up (about 2·43 acres), not necessarily in square blocks, but as rectangular as the nature of the ground demands, or the surveyor requires, along the run of the vein, for the small Government tax of 10 pesos (say 10s.) per annum.

No labour conditions are involved, so naturally this allows of a tremendous amount of "shepherding" of claims. This militates against the due working of any likely mines by foreign companies, as the owners generally demand such a price as to frighten all investigators away. This, I think, may be taken as the prime cause of decay and neglect, as no engineer is going to allow a big cash purchase price for only a hole in the ground, with no reserves blocked out, and very often no road whereby to reach the "mine." The same cry is repeated time and again in Chile that the London capitalists are too exigent and want only developed mines. This, as a matter of fact, is not the case, as nearly all the properties on offer must be approached from the undeveloped point of view. So the owner, frequently refusing quite good offers, goes on paying his "patentes" (taxes), holding his ground until death overtakes him. Then his heirs would thereafter gladly sell for half the original amount demanded, if a capitalist could be found to again take it up.

Stretching along a coast line of some 3,000 miles in length from north to south, the difference in climate ranges from tropical to glacial, and these again are varied by the immense heights to which the Cordillera rises over sea-level. The latitude of 31° between Valparaiso and Coquimbo serves very well as an imaginary boundary line, north of which the country is arid and barren, while south thereof every prospect pleases, and the land might be said to flow with milk and honey. The north suffers not only from lack of transport, but more often from lack of water, and only in rare cases does it hold out an inviting aspect to the inspecting engineer. Again, while the principal industry of the north is mining, that of the south is undoubtedly agriculture, though there are large deposits of coal and a limited mineral wealth of deposits of lower-grade ores, which are found ranging from Coquimbo along the coastal mountains, and down through the central valley to the

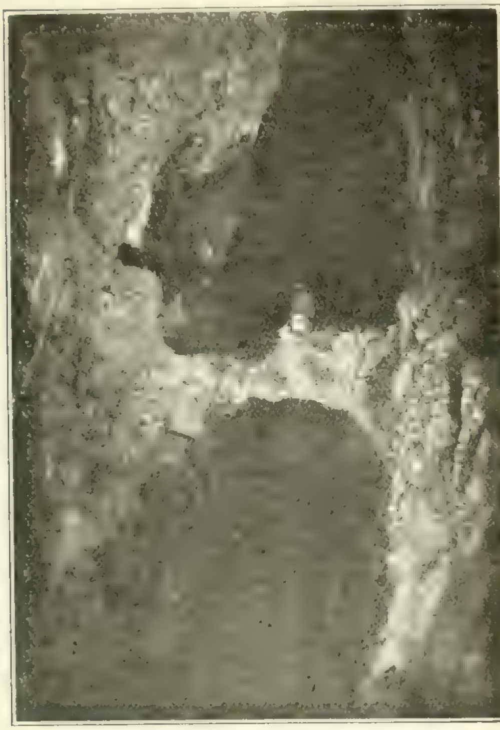


Map of part of Chile.

beach sands of the inlets and fiords of the various straits forming Chile del Sur. Occasionally the gold diggers on the beaches of Chilean Tierra del Fuego, especially after high tides, used to get fair hauls. A progressive Austrian named Popper minted all his own gold himself, in the shape of little coins weighing one gramme. I have one in my possession. On one side are

the words: El Paramo, Un Gramo, Au 864 Ag 132, and crossed miner's hammers; on the other, Tierra del Fuego, Popper, and the date 1889. El Paramo was the name of Popper's mine. The minting is very well done.

Around Tiltil, to the north of Santiago, there are large bodies, or lenses, of heavy pyritic ores carrying gold, which have been worked in a sporadic fashion. They do not lend themselves readily to any simple metallurgical treatment, and so have more or less been relegated to the "shepherded" class of mines. While they



An Old Stope at Lo Mejia

would suit a smelter well for a pyritic flux, carrying a small percentage of copper in addition to the gold, there are none in the neighbourhood, and one which used to be in blast alongside Tiltil station is now dismantled.

At a radius of about 50 miles south of Santiago, and between Rancagua and Melipilla, there are quite a number of low-grade gold-mining propositions suffering from neglect, but rejoicing in a climate that is all one could desire. Unfortunately the "haciendados" (farm owners) in this district do not like, and certainly do not encourage, the prospector to fossick around their fields and camps. If an "extranjero" to the place should take it into his head to go prospecting, then the unanswerable argument of a shot-gun is brought to bear, and the trip is quickly abandoned for fresh fields and pastures new.

On the head waters of the Alhué Creek, at an elevation of some 3,000 ft. above sea-level, the oldest and most extensively worked Minas de Oro de Alhué form a compact, self-contained group of mines. As far back as 1700 the principal lode, the Madariaga—and which to-day the natives call the mother lode of the district—was worked and was mentioned favourably as a gold-producer in the annals of the state. Their old records of yields of so many castillanos per cajon (1 cast. = 4·60 grams, and 1 cast. per cajon = 1 dwt. per ton) can still be consulted, and even to-day approximates to the new development work as a large low-grade ore deposit, easily mined in its oxidized ferruginous workings, but left severely alone whenever hard quartz had to be driven on. Apparently heating the rock and then quenching by water constituted their best means of driving in hard material, and little work was ever done on the quartz veins proper until the advent of a Chilean company about 1880.

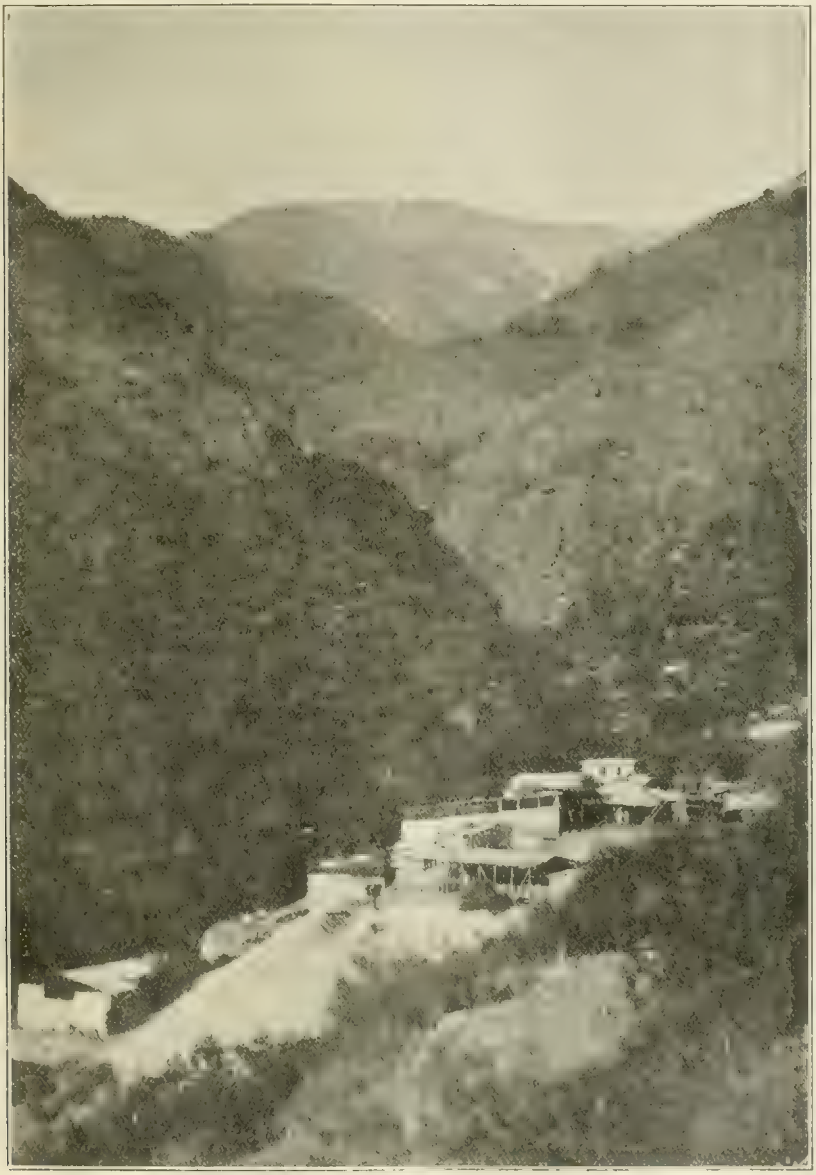
This group of claims, as now owned by the Albion Mining Company, Ltd., include the old Madariaga, Lo Mejia, Flor de Alhué, Profeta, Tribuna, etc., amounting to some 12 in all, cover an area of 105 acres. As is usual in Chilean deposits* the strike of the veins is more or less east and west, but two dip north, ranging from 80° to perpendicular, while the Madariaga and various others conform to the major rule in other districts by dipping south. If one were to generalize on the ground developed, the north-dipping veins show up rather better in average values than the south-dipping veins. The country formation is principally diorite, with strips of schists on the mountain tops 7,000 ft. over sea-level, steeply inclined away from the Alhué valley, so that none of these are visible in the claims. With the exception of one vein, all the lode walls stand well, necessitating no timbering, as is shown in the photograph of an old stope on Lo Mejia. Probably that stope to-day is as good as on the day it was opened, in spite of frequent earthquakes.

The vein matrix is mostly a hard bluish quartz, which in Lo Mejia is freely mixed with rhodonite (silicate of manganese), and when freshly broken shows up a beautiful pink colour. In Flor de Alhué, a bold outcrop on the mountain side carries large quantities of pyro-

* See the article by E. David Pope, The Mining Magazine for June, 1905.

lusite in the oxidized zone, and as may be inferred from the nature of this (according to Spurr), the values are poor until some considerable distance is driven into the ore-body.

in the veins, though where these grade into country without any cleavage wall, generally the hanging-wall side, they form a disseminated link, as it were, between barren rock and



OLD WORKS, WITH CERRO CANTILLANA BEHIND

payable vein stuft. In the case of the rhodonite vein, assays have proved that most of the values are carried in the quartz, while the gold throughout all the claims is in such a fine state of division that no free gold is visible in any stone, a point which certainly tells largely in

A like characteristic to the northern fields of Coquimbo and Atacama is noticed in the Madariaga by the presence of quantities of specular iron ore, generally valueless, which is repeated in two of the neighbouring deposits not far from here. Pyrite is found in very small quantities

favour of the company, as no finger amalgamation takes place.

Metallurgically the ores are ideal for direct treatment, crushing in cyanide solution, combined with counter-current decantation, as they do not filter well, and the consumption of cyanide only runs to about half a pound per ton. In fact, in treating the rhodonite ore alone, over 98% extraction can be obtained for a consumption of ⅓ lb. KCN per ton.

[illegible]

The widths vary from 2 ft. in the Profeta to 49 ft. in the Madariaga, but a good stoping average of the remainder may be taken as 6 ft., while over such a width assays work out about 7 dwt. per ton. When regular stoping work is in progress it is expected this width may be cut down to 4 ft., with a corresponding rise in assay-value to the half-ounce, as the centre foot of the vein carries richer values, ranging up to 27 dwt. According to the books of the previous owners, the ore milled has averaged about the first figure given, and as they only amalgamated over plates, securing an extraction of 50%, the tailings still carry 3·5 dwt.

No shaft-sinking is necessary, at least for years to come, on any of the veins, as the "backs" available from zero levels run up to 1,300 ft., so all the dormant capital involved both in shaft-sinking and winding machinery is entirely obviated.

Water throughout the district is plentiful, and on the property, as can be seen from the photograph, the country is very precipitous, so that heads up to 3,500 ft. can be obtained for power purposes. The mountain peak in the background is the highest on the coastal range, Cerro Cantillana, 7,400 ft. above sea level, and 4,000 ft. above the old works site. During the summer months, from December to April, the water flow is small, but it never runs dry, and with the head available it is expected to yield all the power necessary for an output through the mill of 200 tons per day. Working costs, as may be imagined from the foregoing description, are very low, and when the hydro-electric power plant is installed it is expected that for tonnage treated these will be far below the Rand averages of milling ore of 7 dwt. grade.

There are at least two other large properties in the district with similar characteristics, one of them being well situated for transport to and from the railway station of Rancagua, in the central valley of the country, and an important town on account of the Braden Copper Company's line branching off from here. The properties are, however, "shepherded" by their Chilean owners, and no practical work has ever been done on modern lines, so that these and many others are likely to go on lying fallow until the demands of the owners are moderated.

Climatic conditions, as has already been mentioned, are ideal. Winter, with its snows, and rains, and frosts, is as cold as at home, while the summer is more balmy and never enervating, blankets being a necessity on beds all the year round. The economic features also of the locality, provided as it is with wood, water, grass, and in the valleys all the grain and fruits that heart of man could desire, are such as are rarely met with in a mining camp.

Cooperite. — The secretary of the Zirconium Alloys Syndicate, of 64, Victoria Street, Westminster, writes to *The Times* to say that cooperite, the new cutting medium for machining metal, was tested at the Sheffield Testing Works, on December 1, with the result that at the same speed and feed the tool removed the same weight of steel per minute as the best high-speed steel, but it lasted 21 minutes 21 seconds as compared with 2 minutes 20 seconds for the other tool.

NEWS LETTERS.

TORONTO.

December 13.

METAL OUTPUT OF ONTARIO.—The Ontario Department of Mines reports that the output of the metalliferous mines, smelters, and refining works of the province for the nine months ended September 30 amounted in value to $35,920,418, as compared with $27,875,713 for the corresponding months of 1919. Production during the last two months has been curtailed to such an extent by power shortage that a proportionate increase for the last quarter of the year cannot be expected. The gold output was 424,297 oz. of the value of $8,735,768, an increase of $1,161,182, or 15%. The leading producing mines were: Hollinger $4,620,800, McIntyre $1,603,376, and Dome Mines $1,515,086, the total production of the Porcupine camp being $7,938,649. Silver production increased from 7,475,396 oz., valued at $7,898,220, to 7,831,132 oz., valued at $8,435,088. With the exception of 32,073 oz. recovered from nickel-copper refining and 71,990 oz. from gold-refining operations, the output came from Cobalt, Gowganda, and outlying areas. Nickel was produced to the amount of 7,060,078 lb. valued at $2,440,303, as compared with 7,820,866 lb. of the value of $2,732,676 during the first nine months of 1919, and exports of nickel in matte were 17,446 tons, valued at $8,723,000, as against 11,301 tons of the value of $5,424,552. Copper in matte exported amounted to 9,497 tons, value $2,659,160, as compared with 6,818 tons, valued at $1,908,936. The output of pig iron showed an increase from 30,849 tons, valued at $795,009, to 49,422 tons, valued at $1,395,048.

PORCUPINE.—The output of some of the mines is being seriously curtailed by the shortage of electric power which has continued for some time, the outlook for the winter being dependent on the continuance of open weather and sufficient rainfall to restore the level of the lakes and rivers before winter sets in. So far the weather has been unusually mild for the season, and the supply of power shows some improvement. The Hollinger Consolidated has met the difficulty by the use of an auxiliary steam plant and is steadily increasing its working forces. The company has declared a dividend of 1%, payable December 31, being the ninth to be paid this year, making a total disbursement for 1920 of $2,214,000. Production at the Dome Mines has fallen off temporarily owing to power shortage and the breaking of an underground crusher. About 700 tons of ore are being treated daily, as compared with between 900 and 1,000 tons during the first nine months of the year. This is offset by a considerable improvement in the grade of the ore treated, which is stated to average about $7 per ton, operating costs being estimated at $3·50 per ton. At the McIntyre the new vein system, lying about 400 ft. south of the No. 5 shaft, is being opened up on the 1,375 ft. level, where the vein is 20 ft. wide with high gold content. This development is regarded as of importance to the Hollinger Consolidated, as the system is believed to be a continuation of its No. 84 vein, and its persistence at an equal depth to that proved up on the McIntyre would mean a considerable increase to Hollinger's ore reserves.

KIRKLAND LAKE.—The large new mill of the Wright-Hargreaves with a capacity of 150 tons daily will be completed and ready for operation at the close of the year. The time of starting work will depend on power conditions. The mine is in condition to keep the mill continuously supplied with ore. Most of the development has been on the 400 ft. level, the ore being high in grade. Stations are being opened on the upper levels preparatory to lateral work. As the Wright-Hargreaves location extends for nearly three-quarters of a mile on the main belt of mineralization, having the Lake Shore mine on one side and the Tough Oakes on the other, it is expected to become an important producer. The Lake Shore during October treated 1,570 tons of ore, yielding $47,077, being a considerable increase over the two preceding months. The average extraction of $29·98 per ton made a new high record, and was the highest average ever established by a steady gold producer in Canada. The main shaft is now down 514 ft. The company is keeping production up to normal by the use of steam power. Thackeray Mines, Ltd., which owns 250 acres in the Kirkland Lake area in addition to several holdings elsewhere, has discontinued operations for the season and is planning for extensive development work in the spring. The Hunton-Kirkland is increasing its capital stock from $1,500,000 to $2,500,000.

COBALT.—The silver-mining industry has been hard hit by the drop in the price of silver which, combined with the shortage of power, has considerably reduced the margin of profit, resulting in the closing down of some mines and the passing of dividends by the Mining Corporation of Canada and the McKinley-Darragh. Operating costs are high, the principal item being wages, which remain at the

same figure as when silver was bringing its highest price some months ago. Labour is now plentiful and mine managers are able to pick their men, with the result that efficiency on the part of workers is showing some improvement. The miners are stimulated to increase production by the prospect of being thrown out of work should the mines close down, or of a cut in wages in case the companies resort to this alternative to bring down operating costs to a point which will enable them to continue to work at a profit. Some operators are again storing their bullion in the hope of a better market. The Nipissing during November mined ore of an estimated value of $199,219 and shipped bullion and residue from Nipissing and customs ore of an estimated net value of $232,526. The company, in addition to its regular quarterly dividend of 5%, has declared a bonus of 5% extra. The Chambers-Ferland has made an important discovery of silver at a depth of 385 ft., the deposit being 20 ft. wide and yielding assays of 28½ oz. to the ton. A winze will be put down into the underlying conglomerate where the ore-body is expected to show greater enrichment. The Mining Corporation has discontinued pumping tailings from Cobalt Lake, having stacked a sufficient tonnage to keep the mill running through the winter, thereby effecting a large saving of power. The Beaver Consolidated, which was closed down for a short time while the mill was undergoing repairs, has resumed operations.

GOWGANDA.—The Miller Lake-O'Brien, a privately owned mine which produced 708,872 oz. of silver last year, paid taxes on profits of $451,000. Its profits were exceeded only by those of the Nipissing and Kerr Lake. The Sanderson Syndicate, formed in Montreal pending the organization of a company, has taken over a group of ten claims, comprising approximately 400 acres, in the Gowganda district.

BOSTON CREEK.—At the Miller Independence systematic exploration is being carried on at the 500 ft. level, to examine laterally all the formations not penetrated by cross-cutting, and subsequently to determine the gold content at depth by diamond-drilling. A vein encountered in cross-cutting on the 500 ft. level is being driven on. Henden's Trust, Ltd., whose address is 3, London Wall Buildings, London, E.C.2., has started work on the Hughes-McElroy property, comprising nine claims about 4 miles from Boston Creek, with Frank C. Loring as consulting engineer. The Peerless has resumed operations.

VANCOUVER, B.C.

December 7.

COPPER MINING.—The British Columbia copper-mining industry has received an unpleasant set-back by the closing of the Britannia Mining & Smelting Company's concentrating plant at Howe Sound, and the stopping of the shipping of concentrate to the American Smelting & Refining Company's smelter at Tacoma. The development of the mine will be continued, but fully half of the men have been dropped from the pay-roll. Of late years the Britannia has contributed about one-third of the copper output of the province, while last year it was the only copper property to maintain its rate of production at the level of the previous year. Its output was 17,250,000 lb. of copper out of a total production of 42,500,000 lb., and it also contributed 98,600 oz. of silver and 4,200 oz. of gold to the precious metal output. Ordinarily the mine gives employment to between 600 and 700 men. At the end of last year the ore reserve was estimated at 9,000,000 tons assaying slightly in excess of 2% copper, with small values in precious metals.

Unfortunately also the Granby Consolidated has started to curtail production and has laid off 400 men, and the Consolidated Mining & Smelting, though continuing smelting operations, has stopped all new construction and laid off the men that were working on it. This means that work on the new 2,500-ton concentrator to treat the Rossland ores, the 2,500-ton concentrator to treat the Sullivan mine ore, and the new copper-rod mill has been stopped, pending a better condition of the base metal market.

The Granby, which operates the largest copper smelter in the British Empire, is in a precarious position, as is reflected by the share quotations, which at the time of writing are standing at $20. In 1913 these shares had a low record of $51 and a high record of $78¼, while at one period in 1916 they climbed to $120. Toward the close of and since the war, the company spent large sums of money in improvements, which included the purchase of coal lands, the development and equipping of a colliery, and the erection of by-product coke-ovens and other improvements at its smelter at Anyox. When the investments were made it was intended that these improvements should be paid out of earnings, but with the armistice came the slump in copper prices, and, instead of paying out of earnings, two bond issues had to be floated, amounting to a total of $4,003,300, and these draw an an-

nual interest of $209,198. Metallurgically, the colliery has not been a success. The coal gives a very high-ash coke that has produced trouble in the furnaces, necessitating additional fluxes. Added to this, the title to the coal lands purchased was not clear, and this has plunged the company into expensive litigation. The case is still before the courts; in the last trial title to the colliery was given to the Esquimalt and Nanaimo Railway, a subsidiary of the Canadian Pacific Railway. The Granby has appealed the case, and, in the meantime, in consideration of a deposit the court has allowed the Granby to continue coal-mining operations, but has limited the output. The colliery is now producing about 20,000 tons of coal monthly, a large part of which is sold. Provided that the company ultimately regains title to the coal lands, they should prove to be a good investment. During the financial year ended June 30, 1920, the company earned $1·03 per share. The total output amounted to 23,127,849 lb. of copper, 938,292 oz. of silver, and 14,616 oz. of gold. The main portion of the silver, however, was derived from Dolly Varden ore, which the Granby purchased, the ore acting as a flux to the Hidden Creek ore. The yield approximately was 31 lb. of copper per ton of ore smelted, which was an increase of some 7 lb. over the previous year's operation; the increase being due to the closing of the Phœnix mines, which were playing out and reduced the tenor of the whole.

The Anyox plant is in splendid shape; it has a capacity of 2,500 tons daily, and is capable of producing 44,000,000 lb. of copper yearly. The Granby Company is a United States owned concern and is backed by strong financial interests, and there is no doubt but that a big effort will be made to bring the company once more to the strong position that it has held in the past. There is a considerable amount of unemployment in the province, and there is no doubt but that a lower wage-scale ultimately will obtain, though the miners, who have been enjoying a high wage-rate, will resist it to the last ditch. One thing, however, is pretty certain: with its heavy bonded indebtedness the Granby Company cannot continue to operate profitably under present wage conditions with copper much below 15 cents per pound.

The Canada Copper Corporation is another victim of adverse conditions. After running its plant for rather less than two months, it closed its mine on December 9 and its mill two days later. During this time the plant was never tuned up to more than about one-third capacity. The manager states that the plant was giving complete satisfaction, but that when the price of copper dropped below 15 cents per pound operations ceased to be profitable, and the directors decided on a close-down. Some time before the plant was stopped the men were asked to accept a reduction of 50 cents per day in wages until the copper market improved. This they refused to do, with the inevitable result as recorded. The company has issued the following statement: "Owing to the low price of copper, which has been gradually dropping for the last few weeks until it has reached an alarmingly low figure, it has become necessary to close down the mine and plant at Copper Mountain and Allenby. The Canada Copper Corporation is in a position to operate at as low a figure as any other company, and if the price tends upward to such a figure as concordant with the present cost of supplies and scale of wages will allow the company to make a fair profit, operations will be resumed." It is exceedingly doubtful whether at the present cost of labour and supplies current in British Columbia any company can produce copper profitably when the price of the metal falls below 15 cents.

GOLD MINING. — At the present time, everything points to a considerable falling off in the gold production of the province during the present year. The Rossland mines, which are the principal producers of the province, have been closed for the greater part of the season. They were re-started about six weeks ago (in the beginning of October), but this to a great extent has been off-set by the closing of the Nickel Plate mine at Hedley at the beginning of November. Of late years the Nickel Plate has been producing between twenty and thirty thousand ounces of gold yearly and about $20,000 worth of arsenic. The closing of the mine has thrown more than 100 men out of work, but, as their insistent demand for wage increases has been the main factor in bringing about the closing of the mine, they have only themselves to blame. There is a large reserve of ore that will run better than nine dollars per ton in the mine. In closing the property the manager, G. P. Jones, stated that at the present cost of labour and supplies it was impossible to pay dividends and at the same time maintain the ore reserve, so the only sensible thing to do seemed to be to close the mine until conditions improved. It is probable, he stated, that the mine will be closed for not less than a year.

Placer mining has been at a standstill during the year. Early in the season there was a

shortage of water, the late frosts holding the water in the mountains. During the latter part of the season there has been a superabundance, too much, in fact, for successful operation. Several companies have announced their intention of putting dredges on the Fraser River next year. With the opening of the Pacific Great Eastern Railway into the old Cariboo district, and the consequent increased facility for the transport of machinery, there seems to be every reason why the Cariboo field should be attractive for gold dredging. Without doubt there is a good deal of gold still remaining in many of the rivers that might be profitably extracted by dredging.

CAMBORNE.

GRENVILLE.—The recent meeting of shareholders, called for the specific purpose of winding up the company, was ultimately adjourned to test the suggestion made by Mr. C. V. Thomas that the shareholders should find a sum of £7,000 on security of the assets of the company to enable the property to be nursed for six months, in the hope that by then the tin market would have improved sufficiently to re-commence operations without loss, and capital would be procurable to set the company on its legs again. The consulting engineer (Mr. Josiah Paull) very properly pointed out that meanwhile the mine was filling with water and the plant deteriorating, while the chairman stated that it would simply be courting disaster to re-start with the present ramshackle plant. New plant is estimated to cost from £150,000 to £200,000 at current prices. It is clear that no tin mine in Cornwall, being worked at any depth below adit, even producing ore of a recoverable grade of say 30 lb. black tin per ton and with tin metal at £300 per ton, will be able to show sufficiently encouraging financial results unless equipped on modern lines and managed by men of high technical knowledge and skill. Existing operating costs are unlikely to fall to any considerable extent; wages are not extravagant now, and the principal material cost, coal, is most unlikely to be substantially reduced in view of foreign markets awaiting that commodity as soon as export is permitted and satisfactory terms of payment arranged. It will certainly be folly to re-start without adequate capital; the present company might have weathered the present depression but for the fact that the money provided by the recent reconstruction was quite inadequate. Of the £27,000 raised, all but £5,000 was spent in meeting the old company's liabilities and in reconstruction expenses, and certainly the new money would not have been forthcoming had the then directors made the true position as clear as their duty demanded. However, there is nothing to be gained by criticism in that direction now, and we can only hope that local shareholders, who benefit more largely than outsiders, will have the courage to back their faith and opinions so as to give this fine old mine a further chance.

GEEVOR.—On December 18, 14 days' notice was given to all employees to terminate their engagements, owing to the fact that the mine, under present circumstances, cannot be operated without loss. It is stated in the notice to the employees that increased returns to meet the serious fall in the price of tin cannot be looked for until the new "Victory" shaft has been sunk to a level permitting of the hauling of sufficient stuff to allow the battery to be kept going at full capacity. It seems rather a pity that capital should have been locked up in the enlarged mill so long in advance of mine development, but doubtless the chief responsibility rests with the late manager. Geevor is one of the few mines working to a large extent above adit, and water troubles are not the usual nightmare in this case. We believe that under existing circumstances suspension is undoubtedly the right policy, and we should still express that opinion even if sufficient ore were available for keeping the enlarged mill working to full capacity, for we cannot believe that, with black tin at its present price, any Cornish mine producing only that commodity, can be operated except at a very heavy loss. We recognize that certain standing charges must continue even with operations suspended, but they must be out of all proper proportion in this case if they are not less than the operating loss. Moreover, the reserves would be being depleted with no benefit to the shareholders if working was continued. Presumably the sinking and equipment of Victory shaft will be continued in readiness for the time when stoping operations can be resumed, and this will provide employment for a limited number of men.

LEVANT.—The employees at this adjoining mine have also been given notice, but the situation here is not the same, for the pumps must be kept going unless the mine is to be allowed to fill with water. As the deeper workings are extensive, and as the best prospects, in the opinion of some engineers at any rate, lie in the extension seaward of these workings, it is to be hoped that it will not be necessary to abandon them. The incoming water at Levant is, comparatively speaking, light, and

it would be a thousand pities to have to stop the pumps. Seeing that £60,000 new capital was provided only about a year ago and that no money has yet apparently been spent in sinking the new projected main shaft, the financial position ought not to be such as to necessitate this course, unless indeed the mine has been worked at a heavy loss during the year. Working costs at this mine have for years been abnormally high owing to local circumstances, and always will be until a suitable shaft has been sunk for the proper exploitation of the lower workings.

GIEW.—As further evidence of the desire of the miners themselves to assist the companies to tide over this time of depression, at this mine the men have agreed to hand back to the company the sum of £1 per month per man until the price of tin metal again reaches £260 per ton. This spirit of good will and co-operation is to be commended, and is a heartening sign that in some cases, at any rate, given confidence in the management, the workers are willing to make sacrifices to keep the mines in operation.

TINCROFT. — At this mine, it will be recalled, the employees agreed some time since to contribute £200 per month to assist in meeting the losses being incurred, and recently they adopted and submitted the following gratifying resolution to the directors:

"We convey to the board of directors our sincere gratitude for the splendid and ready response made to our representations for the continuation of working operations during the present period of depression. We fully realize the difficulties you are up against, with the low price of tin now prevailing. It makes matters more difficult, but we have every confidence that our arsenic returns will more than compensate for the drop in price of tin. We can assure you, gentlemen, our very best efforts are being made to obtain the best results, and hope you will find it possible to continue operations during the winter months. Then, with the prospects of trade becoming normal, we may expect much better prices and prosperity for the mining industry."

It is regrettable that the directors have, after all, had to issue notices to suspend operations on January 15. The employees, who number some 200, will now have to draw on the unemployment dole of the Government, whereas if the sum so payable was handed over to the company, operations could be continued. It is hardly to be expected that the Government would adopt any such common-sense policy, although the cost to them would be the same, so it looks as if the end of Tincroft is in sight.

SOUTH CROFTY.—It is satisfactory to learn that the development of what is now termed the No. 2 North lode at the 290 fm. level has proved to average rather over 30 lb. of black tin per ton for the whole length of the drive. This lode has also been intersected at the 260 fm. level north of Robinson's shaft, its value there being 33 lb. black tin over a width of 5 ft.

TEHIDY MINERALS, LTD.—Owing to unexpected difficulties which have arisen in connection with the settlement of the account between the company and the vendors of the Basset Estate, it was found impossible to prepare and present to the shareholders at the recent meeting a statement of account as from the inauguration of the company, and so the meeting was adjourned. However, the report prepared by the general managers, Messrs. Bewick, Moreing & Co., and the statements made at the meeting give a good idea of the activities to date. The first work undertaken by the engineering staff and Dr. Maclaren was the geological examination of the unexplored tin areas in the Camborne-Redruth district. Surveys of the different mines were co-ordinated, a work of no little difficulty, and one general plan of the area and geological plans and sections were prepared showing the exploratory work necessary for the location of the tin-bearing lodes in the hitherto unexplored granite zone north of the present operating mines. The conclusions arrived at by the engineers from this work are stated to warrant the belief that this zone will prove to be a large tin producer when capital is available to finance the necessary development work. The driving of the Tolgus tunnel and the proposed exploratory cross-cut from Dolcoath to the Roskears will prove whether these prognostications are correct, but most certainly the evidence collected justifies up to the hilt these proposed developments.

A preliminary examination has been made of the iron-ore deposits in the Roche, Lanivet, and Withiel parishes, which shows that there are several long lines of lode of reasonable width, carrying shoots of good-grade iron ore which could easily be developed if a market was available for the product. These deposits were worked to a considerable extent before the more cheaply-mined Spanish ores displaced them from the market. Unless a tariff is put on imported iron ores, which is most unlikely, we see no prospect of these deposits ever being tackled.

The most promising, from an early revenue-

producing point of view, of the company's extensive mineral areas appears to be the china-clay deposits in the Bodmin district. In the Temple (South Bodmin) district there are altogether fifteen probable and possible china-clay areas, seven of which are considered by the engineers to be of first-class importance. Until they have been completely explored, their extent and commercial value cannot, of course, be determined, and attention is now being given to the preliminary work relating to the development of one section of these. Already the important question of transport has been successfully tackled by satisfactorily arranging the easements for the necessary pipe-lines. As has already been reported in these columns, the company has acquired an interest in the Cornish Kaolin Co., Ltd., owning and operating china-clay properties in the Bodmin district, and that company has acquired from Tehidy Minerals, Ltd., an adjoining area, which is being paid for in shares.

The policy of the company, in fully investigating its properties before commencing definite operations is thoroughly sound, although to the shareholder, anxious to get a return on his money, it seems slow business. In Cornwall, in the past, much capital has been wasted because of the absence of preliminary investigation work. The general managers of the company appear to be thoroughly satisfied with the result of their investigations, and we trust that, as soon as the general financial position improves, capital will be forthcoming to start operations which will lead, in the words of Captain A. H. Moreing, "to an era of prosperity such as seldom has been equalled and never excelled by any company or body of persons in Cornwall before." These are brave words and perhaps somewhat on the optimistic side, but they are evidence of the confidence of the general managers in the company's future.

CALLOOSE.—The consideration by the Court of the petition for the winding-up of this company was adjourned pending a meeting of shareholders with a view to ascertaining their wishes, and, if it was decided to continue, then on what terms. This meeting was subsequently held, when by a large majority it was decided not to wind up, but as no scheme was presented, a further meeting will consequently have to be held. In a circular issued by the vendor (Mr. A. F. Calvert) of the company's properties, he claims that his opposition to winding up is in the general interests of the shareholders, and that, according to local opinion, the properties will prove profitable. Shareholders disposed to believe that these properties are as valuable as claimed by the vendor will do well to ask for the names and status of the engineers who have expressed that opinion and to call for the publication of their reports, so that they may be examined.

EAST POOL & AGAR.—Since my last letter, yet another lode has been intersected in the cross-cut to the Rogers lode at the 252 fm. level. This lode is believed to be Branwell's lode, and at the point of intersection it shows excellent values. This is the third lode met with in this cross-cut, each of which has assayed well above the milling average. It is evidence of the highly mineralized nature of this part of the mine, and, once the price of tin advances, should enable handsome profits to once again be earned by this company. To judge from the monthly sales and known operating costs, the mine must, at present, be working at a substantial loss, but the splendid development results of the past few months indicate a rosy future once the price of tin improves.

KIT-HILL & HINGSTON DOWN MINES.—The Duchy of Cornwall has abandoned all work at these mines, and the machinery and plant was recently put up to auction. The Duchy was influenced to start work on these properties in 1916 by the then national shortage of wolfram, but difficulties in securing the necessary plant delayed the commencement of milling operations on any scale until early in 1919, by which time wolfram was practically unsaleable. The capital expended on this enterprise amounted to over £75,000, and we fear that this unfortunate experience will discourage the Duchy from undertaking any further exploitation of its many mineral properties in the West of England.

DOLCOATH. — The accounts for the six months ended June 30, 1920, have at last been issued, and a loss is shown of £11,825. This is somewhat less than was perhaps expected, but, from the financial position disclosed by the balance sheet, it is clear that, without further capital, operations could not be continued for long. The tonnage of ore treated for this period was 30,052 tons, from which was produced 338·5 tons of black tin (average recovery 25 lb.) which realized £70,752. The total receipts figure at 49s. 8d., the working costs at 57s. 2d., and the loss at 7s. 6d. per ton milled.

Accompanying the directors' report was the report by Messrs. Bewick, Moreing & Co. on the Roskear scheme. This is given in full in another part of this issue, so that it need only be said here that they are very favourably im-

pressed with the possibilities of the proposed exploratory cross-cut from the Williams shaft to test the granite area between that shaft and the Roskears, the cost of which is approximately estimated at £120,000. To raise this sum, it is proposed to form a new company with a capital of £350,000 (the same capital as the existing company), and to issue one £1 share, 10s. paid, in exchange for each share held in the old company. If fully subscribed, this would realize a sum of £175,000, which would allow for the registration costs of the new company, the payment of outstanding liabilities, and doubtless leave still a margin beyond the sum estimated by the engineers for the proposed exploratory work. The money will be called up by small instalments spread over probably eighteen months, and it may be surely expected that local people will take up all shares not subscribed for by the present shareholders, as the district is so largely dependent on the success of this undertaking. The debenture debt of £75,000 will be continued, and Messrs. H. Montagu Rogers and C. A. Moreing will probably join the board of the new company. The scheme has been very well received, the only criticism we have heard being whether the work can be carried out for the sum estimated. In these times, close estimating is out of the question, and we doubt whether any one has better knowledge than Mr. R. Arthur Thomas and Messrs. Bewick, Moreing & Co. (who substantially agree as to the cost) on which to form a reliable judgment.

NORTH OF ENGLAND.

Lead and Zinc Mining in 1920.—Lead and zinc mining in 1920 has been a long and hopeless struggle against adverse circumstances. The price of pig lead has been subject to violent fluctuations, the mean February average being £50. 12s. 9d. against £21. 10s. on December 16, and spelter, which in February last was £62. 3s. 6d., is now (December 23) £22. 10s. The market for galena has been difficult, as the smelters could not anticipate what additional charges might be placed upon them, and they have been reluctant to enter into forward contracts for ores. Several mines even found difficulty in selling spot lots, except at exceedingly low prices, and a few stocked production in the hope of a more satisfactory price in relation to the price of pig lead. The mine-owner has, however, to accept the position that any additional cost incurred by the smelter has to be added to the returning charge, and every rise in coal or labour has been passed on to the producer of galena. The returning charge was in pre-war days about 40s. to 45s. per ton for high-grade ores, but lately smelters have asked as much as £10. 10s. 0d. f.o.r. I think, however, that galena might be sold at about £7 returning charge, as tentative offers have been received for shipment below this figure.

Certain old contracts are still in force at a much lower returning charge, and the smelters have made no effort to denounce them. We miners have hitherto been always fairly treated by the lead smelters. Taking a returning charge of £7, galena 80% Pb, silver 8 oz., the price in February was £34. 10s. 0d.; in December the same ore was worth £9. 16s. 0d., a drop that is rather startling.

With regard to blende, there is really no market. All the home zinc smelters have now closed down, except Seaton Carew, where there is a small production, and the only real outlet is the Continent. I can give no idea of the price obtainable now, but when spelter was about £48 two fairly large parcels were shipped to Antwerp at a figure that gave the mines about £9 net. With spelter at the present level there can be no resumption of production, the Swansea works finding that £52 is the minimum figure at which they can cover costs. It has been suggested, in influential quarters, that the Government should supply blende at a nominal price as long as large stocks are available, and thus galvanize the corpse into temporary vitality.

The only blende producers who have a certain and satisfactory market are the Australians, and the chairman of the Sulphide Corporation stated on December 22: "For our production of zinc concentrates a satisfactory market is assured through the contract made by the Zinc Producers' Association with the British Government, which runs until 1929." Our Mine Owners' Association has constantly pressed for the inclusion of the home mines in this contract. Verbal promises made during the war have, however, been repudiated, although the whole facts were laid before Sir Robert Horne in June. The President of the Board of Trade did not hurriedly reject our claims, as an answer was only extracted late in December. This was to the effect that the Government refused to place us upon the terms granted to the Colonies. The stock of zinc concentrates purchased is already over 500,000 tons. This is lying at port in Australia, and the current output will be acquired under the contract until 1929. Mr. Bridgeman also states that he cannot recommend the inclusion of our

home mines in the Key Industries Bill. The logic of these eminent gentlemen is unimpeachable. They are buying blende abroad, and by destroying the home producer until 1929 they have at least one competitor disposed of. The differentiation against the home producer is, I hope, unique in the history of muddle and incompetence that has characterized the mining "policy" of the present administration. The effect has been to kill the industry, and the end of 1920 leaves this country without a single blende mine in operation, and a Government buying enormous quantities of blende at a "satisfactory" price, which it is trying to dispose of to the continental smelters.

I do not assert that the Government's hostile policy is the only cause of the present disastrous position. It is perhaps the most important factor, but the costs of material and labour have been steadily increasing during the year. I give a few comparisons, partly from market quotations, and partly from actual invoices.

	1919. per ton.	1920. per ton.
Slack Coal	33s.	43s. 3d.
Anthracite for engines	54s. 1d.	72s. 6d.
Sieving (standard clothing)	£15	£19. 13s. 9d.
Cement	£4 19s. 8d.	£6. 5s.
Gelignite 50%	£140.	£160.
W. Coast Hematite Iron	£10. 4s.	£15. 15s.
Round bars	£21. 15s.	£30. 10s.
Rails	£16. 12s. 6d.	£26.
Bolts and nuts	£45.	£57. 10s.

At one mine (the conditions in the two years being identical) the cost of coal in 1914 was £5,700, and in 1920 £15,000. Replacements have been bought at ransom prices; for instance, trommel cast iron centres 1914, 12s.; 1920, 80s. I need not labour the point, but the coal-miner has in fact obtained his specially favoured position at the cost of the rest of the community.

As to labour, there has been a general rise of 6s. per week, awarded by the Industrial Court, under the ruthless pressure of the Unions, and further claims have been recently advanced. The mines have, however, closed down in the meantime, a quite convincing answer to further claims.

I have heard in several instances of an improved standard of effort among the men, and in some cases the level of output is as high as pre-war. This is all to the good; nevertheless it will have to be realized that the wages in country places cannot be gauged by the standard in industrial centres. A very considerable level of comfort can be maintained with a much lower scale of wages in isolated districts.

I am not familiar with all mining areas, but I think it would be safe to say that no mines are covering the cost of production, and with those still in operation, the object is to see if the present crisis can be tided over.

In Cumberland, Greenside is still producing galena, but the company has gone into liquidation, and is merely engaged in crushing its large stocks of crude ore. This important mine will sell its plant some time next year, and permanently close down. Threlkeld mine, worked by adit level, has suspended production, but the owners are keeping on the men for a few months on the development of the large area of "payable" lode that has recently been laid open. Brundholme mine has no production yet, but is arranging with the Threlkeld lessees to follow a nice-looking lode into their area. Thornthwaite has quite definitely closed down for the present, about 10 men, including the staff, being retained to keep the pumps in operation and the mine in working order. Force Crag is stopped except for a few men trying a barytes deposit.

Further east in the Alston-Nenthead district, the Vieille Montagne Zinc Co. has a few men working at Nentsbury, where there is quite a nice lead deposit, but the large concentration plant is idle, and I very much doubt if milling will be resumed there. Across the Pennines, Weardale is still running with an output of over 200 tons of galena per month, but I am pretty certain that heavy losses must be now incurred with pig lead at £21. 10s. The wages in this area are the highest in the industry. Despite this fact, the 6s. advance was awarded against this company, bringing up wages to an average of 25s.–30s. per week beyond those of, say, Wales. At Lord Allendale's mines there are some encouraging developments, but I hear that they may be shortly closed down. The output is not important at present.

Taking the Scottish area, Tyndrum is practically standing, but with fair prices I believe this mine may become an important producer. At the Newton Stewart mines production has been suspended. The important Scottish mines are, of course, Leadhills and Wanlockhead. Both are looking well underground, and with fair prices would be a permanent source of supplies. They both have deep shafts and heavy pumping charges. At the moment they are in operation, but with the heavy losses now being incurred their stoppage may be anticipated. This would be a disaster to the district, as the whole population depends upon the mines. If the pumps are stopped the cost of reopening would be enormous, but the shareholders may well object to spending £20,000, at each mine,

in pumping charges for a year, with no certainty of profit at the end of this period.

In Wales, East Halkyn has now definitely closed down, and there are rumours that the plant is to be sold. The pumping charges here are very heavy indeed. The only other mine in active operation is the famous Halkyn mine, and matters have now reached an acute crisis; by the time this appears, operations will probably have ceased. The future of this district absolutely depends upon the successful prosecution of the deep drainage tunnel, which has been driven a long way already, but work was suspended in August, 1919, and so far it has been impossible to devise any scheme that would satisfy the claims of the various interested parties. The Government advanced large sums during the war, but additional capital is required to complete the work. A conference was held under the chairmanship of Sir Charles Stewart, but proved abortive. I do trust that further efforts may be made, as the scheme is absolutely sound in its conception. It would unwater the following mines in the order named: New North Halkyn, Halkyn, Mount Halkyn, Bryngwiog, East Halkyn, North Hendre, South Halkyn, Llynpandy, Pantymwyn; giving a further depth of 200 ft. free of water to most of them, but in one case at least 350 ft. To show the importance of the tunnel, East Halkyn sunk its shaft about 90 ft. below the old tunnel, and had to pump a steady flow of 4,000 gallons per minute to keep the workings clear of water; yet, despite the richness of the deposit, the cost of pumping has now rendered it impossible to work the mine. The mines mentioned are, more or less, equipped with concentration plant. To an outsider it is difficult to believe that a comprehensive scheme cannot be devised by which the royalty owners, the Tunnel Co., the Government, and the mine-owners would mutually benefit.

In the Llanidloes district, the Van and neighbouring mines are idle, through the usual causes, and the new equipments erected are so far wasted. Esgairmwyn mine has stopped, but a development policy is under consideration by the owners. The Lisburne Syndicate at Frongoch and Glogfawr has erected a large plant, but work is now suspended.

In the Shropshire district practically the whole mineral area is in the hands of the Shropshire Mines, Ltd., and Lieut.-Col. J. V. Ramsden is conducting large operations there. The output of galena up to the present has been very small, but the potentialities of the district are enormous. There is here a large drainage tunnel called the Leigh Level, and the company is driving this right under the group of mines, in order to unwater the whole area. The scheme is being carried out on broad lines and with the most modern appliances, and should eventually prove a source of great mineral wealth. It is intended to sink the Bog shaft a further 300 ft. In the meantime the company has concentrated its efforts on the production of barytes, which happily is still saleable. The output of barytes during 1920 was 8,300 tons. The present number of men employed on development work and the production of barytes is about 300.

I have no further news of the Mill Close mine, Derbyshire, but the huge cost of pumping there must be giving the owners some anxiety.

On the basis of anything like the present level of prices and costs, the future looks hopeless, but I do not consider that the quotations for either metal represent in any way the intrinsic value. The holders of metals are raising cash at any sacrifice, actual consumption having fallen quite suddenly to a very low ebb. The banks cannot finance dealers, who would otherwise have held their stocks, and no one is buying who can postpone orders. The consumption in Europe is far below normal, despite the necessity of reconstruction, and the world's production has fallen to far below pre-war standards. The Broken Hill output ceased through the strike, and operations are not being recommenced because of low prices. The present level is now below that at which the Burma Corporation originally stated it could profitably produce concentrates. When the normal demand arises, there must be a serious shortage, and then both metals must appreciate in price to the point at which equipped mines can operate.

To illustrate this, the world's production of pig lead in 1913 was estimated at 1,142,264 tons, a drop of 130,012 tons on 1912. We have no information as to the output during 1919 from many countries, but there is now no considerable Australian production and the United States output has steadily fallen for the past four years; indeed, wherever there is any accurate information the output is down. I hardly think that the world's production at the present moment is more than 800,000 tons per annum. The statistical position of zinc is equally striking. The world's production in 1913 was about 980,000 tons, and in 1919 about 570,000 tons, and to-day is probably not more than 500,000, a generous estimate. When one considers the requirements for reconstruction in Europe, including England, it is quite evi-

dent that the present lack of demand is only temporary, and that there must be a rapid alteration in the situation.

Capital will not be attracted to the mining industry either here or abroad until there is some evidence of substantial profits, and we need not fear the opening of new fields at the present moment. After all, the smelters cannot produce lead or spelter without ore, and no ore will be raised if it does not pay to mine it. Personally I anticipate a fairly long period, say six months, before there is a steady consumption, and then there should be a period of super-normal demand, which may last several years. The important thing from our point of view is whether we can compete against foreign countries. This depends on the cost of labour and materials and the quality of our deposits. We have few natural advantages, and many artificial disadvantages, among which may be mentioned royalties, rates, taxation, and the cost of acquiring land and disposal ground. Evidence was given by our Association at the Non-Ferrous Metal Inquiry of the crushing nature of these, and recommendations were made to the Government, all of which have been ignored.

With regard to labour, I am more than ever convinced that a new and better standard of effort can be obtained if the mine-owners will seriously face the formation of Consultative Works Councils, with wages based on the success of individual mines as a whole. The present method of contracts underground is thoroughly bad, and is the antithesis of co-operative production. We want intelligent team work, and I am quite sure that if this can be achieved we shall increase our production per man by 20% to 25% without any slave-driving pressure. I have found that men respond readily if they only know the facts, and every man on the mine should be placed in the position of seeing the collective result of his effort. I should like to enlarge on this important factor, but the editor can hardly give me space.

Taking the lead and zinc mines in the United Kingdom, there were 1,501 underground workers and 1,475 surface workers in 1919. The effect of the existing conditions is that most of these will be on the unemployed list within a month or two. These figures include mines that were in course of development, with an abnormal number of surface workers engaged on the erection of plant, but if these non-productive mines are excluded the figures would of course be much smaller. My advice to mine-owners is to hold on as long as they can, as the present depression is quite artificial, and one hopes that the world will soon show signs of recovery from the destitution that is now its lot.

PERSONAL.

R. A. Archibald has left for Madras.

C. P. C. Beresford has recently been appointed consulting engineer to the interests controlled by S. I. Patino in Bolivia, and left England on December 31.

Max W. von Bernewitz has rejoined Walter Harvey Weed in compiling the "Mines Handbook." The office of the Handbook is at Tuckahoe, New York State.

A. E. Bidlake has gone to Oruro, Bolivia.

F. K. Borrow has left for the Frontino & Bolivia Company's gold mines in Colombia.

V. W. Boyle has left for Nigeria.

Dr. W. H. Collins has been appointed director of the Canadian Geological Survey.

V. J. Edwards has left for Portugal.

J. P. Grenfell is back from the Transvaal.

George A. Harrison, who was out for the Russo-Asiatic Consolidated, has returned from Siberia.

Ross B. Hoffmann is here from the United States.

Austin Y. Hoy, London manager for the Sullivan Machinery Company, is back from the United States.

J. H. Ivey has resigned as manager of the Poderosa mine, Chile, and is now in charge of the Corocoro Company's copper mines in Bolivia.

R. C. Jennings has gone to Venezuela.

C. E. Jobling is returning from Sweden.

A. A. Kelsey has left for Mexico.

N. S. Kelsey has been appointed manager of the Tomboy Company's mines in Colorado.

E. A. Knapp is expected from Nigeria.

W. J. Lakeland has gone from Burma to Ballarat.

F. H. Lathbury has gone to Selangor, Federated Malay States.

F. H. B. Leggett has gone to Burma.

W. J. Loring has been elected president of the American Mining Congress for 1921.

V. F. Stanley Low has gone to Sweden.

R. Macfee has gone to Algeria.

H. Mackay has gone to Colombia.

T. Bruce Marriott has left for South America.

J. A. McKinlay has gone to Burma.

A. H. P. Moline, manager of the Bendigo Amalgamated Goldfields, is visiting the United States.

J. W. Newbery has gone to Burma.

Eric Newbold has gone to New Mexico.

R. E. Palmer has gone to Spain.

Frank Powell is leaving for Colombia on January 18.

R. Allison Purvis has joined the staff of the Marmito Mines, Ltd., Colombia, and left on December 16.

R. Quance has gone to Dunkwa, West Africa.

Edgar P. Rathbone is with the Upper Silesia Plebiscite Commission, at Oppeln, Silesia.

William Russell, London manager for the Dorr Company, has returned from the United States.

W. P. Rutherford, managing director of the Tharsis Sulphur & Copper Co., has been appointed chairman in succession to the late Lord Glenconner.

D. A. Sutherland has left for South America.

A. E. Taylor has left for India.

E. O. Teale has left for Tanganyika Territory to make a new geological survey for the Colonial Office.

David M. Thompson, formerly an engineer with the Naraguta (Nigeria) Tin Mines, Ltd., has joined the board of the National Engineers' Supply Company, Ltd., of Liverpool.

E. F. V. WELLS has been appointed manager of the Tweefontein Collieries.

A. HEDLEY WILLIAMS is at the Lobitos oilfields.

E. W. SANDEMAN, secretary of Ipoh Tin Dredging, Ltd., died on January 1.

CURTIS H. LINDLEY, the eminent San Francisco lawyer, and the author of the handbook, "The American Law Relating to Mines and Mineral Lands," died last month.

MATTHEW T. WIGHAM, secretary of the New Rand, Ltd., and other companies, died last month. He was born in Northumberland in 1854, and joined the late T. J. Bewick as personal secretary, becoming subsequently secretary of some of Mr. Bewick's companies. For a short time he served in London in the same capacity with Bewick, Moreing & Co. Subsequently he became associated with the Hon. H. Finch Hatton. Of recent years he was known among mining engineers as the secretary of the New Rand, Ltd., Arthur Sawyer's enterprise for testing ground in the Orange Free State.

TRADE PARAGRAPHS

BOVING & CO., LTD., of 56, Kingsway, London, W.C.2, have issued a leaflet describing their low-lift pumps.

MILLARS' TIMBER & TRADING CO., LTD., of Pinners Hall, London, E.C.2, have issued a pamphlet describing their air-compressor, which is suitable for application for all sorts of purposes, for instance, rock-drilling, caulking, rivetting, and pneumatic painting.

THE INTERNATIONAL BARGE SUPPLY & TRANSPORT CO., LTD., of 5, Lloyd's Avenue, London, E.C.3, send us a pamphlet containing specifications and drawings of steel lighters and motor-driven barges, suitable for short coastal journeys or inland water traffic.

THE WESTINGHOUSE ELECTRIC INTERNATIONAL COMPANY, of 2, Norfolk Street, Strand, London, W.C.2, send us Motor Application Circular No. 7,132, which is devoted to a description of electrically-driven shovels used for digging and moving earth and broken rock.

HEAD, WRIGHTSON & CO., LTD., of Stockton-on-Tees, well known for their manufactures in connection with mining, such as cyanide vats, head-frames, tube-mills, Nissen stamps, etc., have commenced the manufacture of a number of metallurgical and mining specialties by arrangement with the Colorado Iron Works Co., of Denver. These are as follow: The Convertible Discharge Ball-Mill, a short mill fitted for either grate or open discharge; the Rod Mill, a cylindrical mill using rods instead of balls as the grinding medium; the Akins Classifier, a highly efficient machine of simple construction; the Impact Screen, a mechanically-operated high-capacity screen; the Lowden Dryer, a machine for handling flotation concentrate and other materials of a sticky nature; and the Skinner Roasting Furnace, a vertical multiple-hearth furnace of improved construction.

THE DORR COMPANY, of New York and Denver (London Office: 16, South Street, London, E.C.2), have issued Bulletin 19, describing the Dorr Washer. This machine is the result of a demand for a more economical installation, both in initial and operating cost, than was previously used for washing iron ores. While the washer was developed primarily for washing iron ore, it has a wide application in other fields for washing and classifying mixed, coarse, and fine materials such as gravel, crushed ores, etc. It is a combination of the Dorr classifier with a trommel partly submerged below the water level at the lower end of the classifier tank. As applied to iron-ore washing, the feed consists of the undersize from a grizzly, with the bars spaced about 6 in., and is introduced through a suitable hopper into the upper end of the trommel. The washed oversize is discharged from the lower end of the trommel with from 8% to 12% moisture. The undersize passes through $\frac{3}{8}$ in. or $\frac{1}{2}$ in. openings in the trommel into the classifier tank, where it is separated into two products. The coarse material is discharged at the upper end of the classifier with from 10% to 15% moisture after having been washed free from clay and the finer material, due to the action of the rakes and spray water added above the water level in the classifier. The fine silicious and clayey material overflows with the water, together with a small amount of fine ore, and is discharged to waste, or in some cases treated on tables. The concentrate consists of the trommel oversize and coarse product from the classifier.

METAL MARKETS

COPPER.—The downward course of values made further progress during the month of December. This, of course, was partly due to sympathy with the whole trend of world's prices, but at the same time the copper situation in itself has not been by any means a strong one. The big surplus stock held by the American producers still hangs as a kind of threatening cloud over the market, and the difficulty of disposing of this has necessitated further price cuts on the part of the producers in the United States. Meanwhile consumption both there and here has been quiet, and although consumers in this country are still fairly actively employed on old contracts, new bookings show a tendency to diminish, and with the price slipping away there is little inducement to buyers to take hold of any quantity of the metal. In the United States there is a general tendency to curtail production. This, however, will take some time to affect the situation of stocks. In the meanwhile, up to October at all events, in spite of the curtailment already in effect, production was apparently on a larger scale than in pre-war years. It is therefore not surprising that the big stock of copper which accumulated as a result of the cessation of the war has been difficult to disperse. Another thing which may have a considerable bearing on the situation is the tendency to reduce wages in many of the copper districts of America, thus automatically reducing the cost of production. Reports from Spain state that the Rio Tinto strike has been settled following upon the intervention of the Minister of War. The men, it is understood, accepted the company's terms, reserving the right to discuss certain features later. From reports in regard to the Cape Copper Company's operations it would appear that they have been shipping part of their copper to America for sale. It would seem that some changes are being made in selling arrangements in America. The output of the porphyry companies is apparently to be sold by Messrs. Guggenheim Bros. instead of the American Smelting & Refining Co. It is understood also that the latter company will lose the sale of the output of the Cerro de Pasco Copper Corporation, which will be handled by the American Metal Company, while the Tennessee Copper Company will transfer the sale of their product from the American Smelting to Adolph Lewisohn & Son. It appears that Mexico has lifted the export duty on copper ore going to the United States until the price of copper on the New York market is above 15 cents. It is reported from Melbourne that the directors of the Hampden Cloncurry Copper Mines have

DAILY LONDON METAL PRICES: OFFICIAL CLOSING
Copper, Lead, Zinc, and Tin per Long

COPPER

	Standard Cash	Standard (3 mos.)	Electrolytic	Wire-Bars	Best Selected
Dec.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.
[illegible]	[illegible] to [illegible] 0 0	73 0 0 to 73 5 0	89 10 0 to 90 10 0	90 0 0 to 90 10 0	87 0 0 to 88 0 0
[illegible]	[illegible] to [illegible] 0 0	76 10 0 to 76 15 0	87 10 0 to 89 0 0	88 10 0 to 89 0 0	87 0 0 to 88 0 0
14	75 15 0 to [illegible] 0 0	[illegible] to 75 15 0	87 10 0 to [illegible] 0 0	88 10 0 to 89 0 0	85 0 0 to 86 0 0
15	[illegible] to 75 15 0	[illegible] 10 0 to 75 15 0	87 0 0 to 89 0 0	88 0 0 to 89 0 0	85 0 0 to 86 0 0
16	[illegible] to [illegible] 10 0	75 [illegible] 0 to 75 10 0	86 10 0 to 88 10 0	[illegible] 10 0 to 88 10 0	85 0 0 to 86 0 0
17	74 5 0 to 74 10 0	74 5 0 to 74 10 0	86 0 0 to 88 0 0	87 0 0 to 88 0 0	84 0 0 to 85 0 0
[illegible]	74 0 0 to 74 [illegible]	74 5 0 to 74 10 0	85 0 0 to 87 0 0	86 0 0 to 87 0 0	84 0 0 to 85 0 0
[illegible]	73 10 0 to 73 15 0	73 15 0 to 74 0 0	84 0 0 to 85 10 0	85 0 0 to 85 10 0	82 0 0 to 83 0 0
[illegible]	73 0 0 to 73 5 0	73 10 0 to 73 15 0	83 0 0 to 85 0 0	84 0 0 to 85 0 0	82 0 0 to 83 0 0
[illegible]	[illegible] to 72 10 0	73 0 0 to 73 5 0	82 0 0 to 84 0 0	83 0 0 to 84 0 0	82 0 0 to 83 0 0
[illegible]	71 0 0 to 71 10 0	73 0 0 to 73 5 0	82 0 0 to 84 0 0	83 0 0 to 84 0 0	82 0 0 to 83 0 0
29	[illegible] 0 to 70 15 0	72 5 0 to 72 10 0	80 0 0 to 83 0 0	82 0 0 to 83 0 0	82 0 0 to 83 0 0
[illegible]	72 0 0 to 72 5 0	73 5 0 to 73 10 0	80 0 0 to 83 10 0	83 0 0 to 83 10 0	82 0 0 to 83 0 0
31	[illegible] to 72 0 0	73 5 0 to 73 10 0	80 0 0 to 83 10 0	83 0 0 to 83 10 0	81 0 0 to 82 0 0
Jan.					
[illegible]	71 10 0 to 71 15 0	73 0 0 to 73 5 0	80 0 0 to 83 10 0	83 0 0 to 83 10 0	81 0 0 to 82 0 0
4	72 [illegible] to 72 5 0	73 5 0 to 73 10 0	80 0 0 to 83 0 0	82 10 0 to 83 0 0	80 0 0 to 81 0 0
5	72 7 6 to 72 10 0	73 5 0 to 73 10 0	80 0 0 to [illegible] 0 0	82 10 0 to 83 0 0	80 0 0 to 81 0 0
6	72 15 0 to 73 0 0	73 15 0 to 74 0 0	80 0 0 to 82 10 0	81 10 0 to 82 10 0	80 0 0 to 81 0 0
7	73 0 0 to 73 5 0	74 0 0 to 74 5 0	80 0 0 to 83 0 0	81 10 0 to 83 0 0	80 0 0 to 81 0 0
10	74 0 0 to 74 5 0	74 15 0 to 75 0 0	81 10 0 to 83 10 0	82 10 0 to 83 10 0	80 0 0 to 81 0 0

decided to cease operations pending an improvement in the metal markets.

Average price of cash standard copper: December 1920, £75. 16s. 8d.; November 1920, £84. 18s. 6d.; December 1919, £103. 17s. 1d.; November 1919, £98. 18s. 9d.

TIN.—This market has as usual fluctuated, but not to an extent that is anything remarkable for this metal. In the earlier part of the month some strength was shown, but subsequently values eased off, touching the lowest levels since the great rise in February, 1920. The chief feature of interest has been the arrangement come to whereby the Federated Malay States Government takes over the unsold supplies from the smelters there at 115 dollars per picul, this figure representing a value of £236 landed here. It was also reported that the Dutch interests in Batavia were negotiating with the Straits interests with a view to coming to some agreement in regard to the maintaining of prices. From the fact that these two grades of tin, which represent such very important supplies, were going to be strongly held, it might naturally be supposed that strength would be seen in the market, but the opposite was the case. This must be attributed to the general pessimism and weakness in all markets everywhere, combined with the fact that the actual demand for the metal from consuming centres was poor. America has been working for some time on her stocks, and even the fixing of the price in the Straits does not seem to have induced her to buy on any important scale. Meanwhile consumption in this country is also poor, the tinplate industry being in a bad way. Works generally are slowing down in their operations and talk of stopping altogether. The standard market here is now virtually based on Chinese and English tin, the latter having been more or less a drug on the market, with the result that it was being delivered against standard contracts at the fixed allowance of £7 per ton. For both Straits tin and Banka tin on spot premiums are realizable, but even adding the premium for Straits on to the price of standard tin it has been obtainable on spot at considerably less than it could be replaced in the East.

Average price of cash standard tin: December 1920, £212. 11s. 8d.; November 1920, £241. 5s. 6d.; December 1919, £314. 5s. 1d.; November 1919, £283. 13s. 7d.

LEAD.—Like other metals the market for this article also came to lower levels during the month of December. The primary cause of this seems to have been liquidation of stocks of lead which under present tight financial conditions it was becoming burdensome to carry. Another feature, however, has been that America has been at times selling lead here, and arrivals have been fairly heavy not only from Spain, but also from America and Germany. It has been rumoured that smelting operations in Australia may not be recommenced quite so soon as was expected in view of the depression in the markets, but whether this be correct or not the report had no effect on the market here, the fact being that there is plenty of lead in sight for the moment, and consumptive demand has been poor. It is stated that owing to the decline in lead and zinc prices the board of the Broken Hill South mine wish to have time to review the situation, and all productive operations except the slime plant are discontinued until January 10. It seems to be generally anticipated that early in the New Year the demand for manufactured lead products will revive, but this of course remains to be seen, and meantime it looks as if the trade might be able to subsist upon the arrivals continually coming in without making any great inroads upon the stocks in this country, which increased by over 4,000 tons during the month of December.

Average price of soft pig lead: December 1920, £24. 11s. 10d.; November 1920, £32. 5s. 6d.; December 1919, £41. 7s. 8d.; November 1919, £34. 16s.

SPELTER.—This metal also declined to a marked degree during the month of December, the price indeed coming to quite a normal pre-war level. As in the case of other metals, the chief reason has been the paucity of demand from consumers, the galvanizing trade having experienced a great lack of fresh orders. Meanwhile Germany has been selling. At one time some demand was experienced here from America, and it is understood a fair line was sold to that country. This business was of course attracted by the comparatively low prices ruling here. Of course America has plenty of spelter of her own, and the removing of supplies of the metal to a producing country is rather an

Prices on the London Metal Exchange.
Tons; Silver per Standard Ounce; Gold per Fine Ounce.

Lead: Soft Foreign	Lead: English	Zinc (Spelter)	Standard Tin: Cash	Standard Tin: 3 mos.	Silver: Cash	Silver: Forward	Gold	
£ s. d. £ s. d.	£ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.			s. d	Dec.
25 15 0 to 26 10 0	28 0 0	30 5 0 to 31 15 0	223 0 0 to 223 10 0	226 0 0 to 226 5 0	38⅞	39	118 10	10
24 7 6 to 25 0 0	26 10 0	28 10 0 to 30 0 0	215 0 0 to 215 10 0	218 0 0 to 218 10 0	40⅞	41	118 9	13
23 0 0 to 24 5 0	25 0 0	28 0 0 to 29 15 0	212 10 0 to 213 0 0	216 0 0 to 216 10 0	40⅝	40¾	118 7	14
22 10 0 to 23 15 0	25 0 0	25 15 0 to 27 10 0	217 5 0 to 217 15 0	220 0 0 to 220 10 0	42⅝	42¾	117 10	15
22 10 0 to 23 0 0	24 0 0	25 15 0 to 27 10 0	215 0 0 to 215 10 0	218 0 0 to 218 10 0	41⅞	41⅞	117 6	16
22 5 0 to 24 0 0	25 0 0	25 15 0 to 27 5 0	211 0 0 to 211 10 0	215 0 0 to 215 10 0	41	41⅛	116 2	17
23 5 0 to 24 10 0	25 10 0	26 0 0 to 27 7 6	207 10 0 to 208 0 0	211 5 0 to 211 10 0	40	40⅛	117 5	20
22 10 0 to 23 10 0	25 0 0	25 5 0 to 26 15 0	205 5 0 to 205 15 0	210 0 0 to 210 10 0	40	40	115 9	21
21 15 0 to 22 10 0	24 0 0	24 0 0 to 25 7 6	202 0 0 to 202 10 0	207 5 0 to 207 15 0	40½	40½	116 6	22
21 10 0 to 22 15 0	24 0 0	22 10 0 to 24 12 6	198 0 0 to 199 0 0	205 0 0 to 206 0 0	40⅝	41	115 8	23
21 10 0 to 22 15 0	24 0 0	24 0 0 to 26 0 0	200 0 0 to 200 10 0	205 15 0 to 206 0 0	42	42	116 10	28
22 0 0 to 23 10 0	24 10 0	26 0 0 to 28 0 0	200 0 0 to 201 0 0	206 0 0 to 206 10 0	43	43½	116 9	29
23 10 0 to 24 10 0	25 10 0	27 0 0 to 28 0 0	207 0 0 to 208 0 0	212 0 0 to 212 10 0	41¾	41⅞	116 4	30
23 10 0 to 24 5 0	25 10 0	26 0 0 to 27 10 0	205 10 0 to 206 0 0	210 5 0 to 210 10 0	40⅞	41¼	116 1	31
								Jan.
24 5 0 to 25 0 0	26 5 0	26 12 6 to 28 0 0	206 10 0 to 207 0 0	211 10 0 to 212 0 0	41¾	41⅞	115 11	3
24 10 0 to 25 0 0	26 5 0	26 12 6 to 27 15 0	205 10 0 to 206 0 0	210 10 0 to 210 15 0	41¾	41⅞	115 10	4
23 5 0 to 24 0 0	25 5 0	26 7 6 to 27 7 6	205 10 0 to 206 0 0	209 15 0 to 210 5 0	42⅓	42⅓	114 10	5
22 15 0 to 23 10 0	24 15 0	25 5 0 to 26 5 0	208 5 0 to 208 15 0	213 5 0 to 213 15 0	42½	42½	112 2	6
23 10 0 to 24 0 0	25 10 0	25 7 6 to 26 2 6	210 10 0 to 210 15 0	215 15 0 to 216 0 0	41½	41⅝	113 3	7
24 0 0 to 24 10 0	26 0 0	27 2 6 to 27 17 6	210 0 0 to 210 10 0	215 0 0 to 215 10 0	40⅛	40	112 6	10

abnormal feature. Dealers could, however, buy in this country at less money than in the United States and so buying orders came to this side. At the moment the whole situation is rather difficult to read. The price is admittedly low, but as already stated the demand is poor, and further offers may yet be seen from the Continent. It appears that the Federation of Belgian Producers has fixed a selling price at 182·50 frs. per 100 kilos, working out at something like £34. 15s. London terms. This price is of course far above the market level here, and it seems doubtful whether the Belgian producers can hold on till the market recovers to that level. It is understood that the Electrolytic Zinc Company's works at Risdon, Tasmania, are ceasing operations till the metal markets improve, although constructional work will continue. The Welsh zinc smelters are still closed, and there is little likelihood of any resumption of work for some time to come.

Average price of spelter: December 1920, £28. 11s. 6d.; November 1920, £35. 14s. 7d.; December 1919, £53. 9s. 2d.; November 1919, £46. 17s. 3d.

Zinc Dust.—High-grade Australian zinc dust is quoted at £70 to £80 per ton, with English at £75 to £85 and American at £70 to £80.

Antimony.—English regulus of ordinary brands is quoted at £42 to £45 per ton, and special brands at £43. 10s. to £48 per ton. Foreign regulus is easy, and can be had on spot at about £35 per ton.

Arsenic.—Business is quiet and the market is easy, the price being about £55 to £60 per ton for Cornish white.

Bismuth.—The quotation still continues at about 12s. 6d. per lb.

Cadmium.—The current quotation is about 6s. to 6s. 6d. per lb.

Aluminium.—For home and export the price rules at £165 per ton.

Nickel.—The price stands at £215 for home and export.

Cobalt Metal.—The present quotation is about 27s. to 30s. per lb.

Cobalt Oxide.—Black oxide is quoted at about 17s. 6d. and grey at 18s. 6d. per lb.

Platinum.—The market has been weak, and the quotation is now about £16 per oz.

Palladium.—The demand for this metal is also slackening, and the price is quoted at £16 per oz.

Quicksilver.—This metal has only been in very quiet demand. The price of Spanish was reduced by the leading interests to £14 per bottle, and later to £12 per bottle, afterward recovering to £12. 10s.

Selenium is still quoted at from 10s. 6d. to 13s. per lb.

Tellurium is also unaltered at from 95s. to 100s. per lb.

Sulphate of Copper.—Prices are rather easier, and now stand at about £38 to £40 per ton.

Manganese Ore.—The quotation is about 2s. 6d. per unit c.i.f. U.K. or Continent.

Tungsten Ores.—Wolfram 65% is quoted at about 17s. 6d. to 18s. 6d. per unit c.i.f.

Silver.—On December 1 the quotation of spot standard bars was 44⅝d. per oz., values declining until they touched 38⅞d. on December 10, rising again to 43d. on December 29. At the end of the month the quotation was 40⅝d.

Graphite.—There is little fresh in this market. The price of soft velvety flake 85 to 90% is about £60 to £80, and Madagascar 80 to 90% about £21 to £25 per ton.

Molybdenite.—85% is quoted at 55s. to 60s. c.i.f. U.K.

Chrome Ores.—The current quotation for 48 to 52% is about £8 per ton c.i.f.

Iron and Steel.—These trades are in a somewhat transitional state. Prices were of course abnormally high during the boom period, and the readjustment has been slower in these than in the case of most other commodities. With demand falling off, and much lower prices being quoted for both pig iron and steel by Continental countries, it was inevitable that the prices of home makers should be readjusted. Cleveland ironmasters early in January met the situation by marking down their prices by 10s. to 20s. Makers of manufactured material are naturally easier in their attitude as regards prices, and although reductions have been made in certain descriptions and makers generally are willing to book actual orders when these are submitted at shaded quotations, a more general marking down in prices seems still to be due.

STATISTICS.

Production of Gold in the Transvaal.

	Rand	Elsewhere	Total	Price of gold per oz.
	Oz.	Oz.	Oz.	
Year 1919	8,111,271	[illegible]	[illegible]	[illegible] d.
January 1920	653,295	17,208	670,503	107 6
February	607,918	17,412	625,330	110 0
March	[illegible]	17,391	707,036	105 0
April	667,926	19,053	686,979	102 6
May	681,551	17,490	699,041	105 0
June	699,199	[illegible]	715,957	102 6
July	718,521	17,578	736,099	105 0
August	683,604	18,479	702,083	112 6
September	665,486	16,687	682,173	115 0
October	645,819	16,653	[illegible]	117 6
November	618,525	15,212	633,737	117 6

Natives Employed in the Transvaal Mines.

	Gold mines	Coal mines	Diamond mines	Total
September 30, 1919	[illegible]	12,392	5,294	186,806
October 31	167,499	12,691	4,492	184,682
November 30	164,671	12,565	4,337	181,573
December 31	166,155	12,750	4,271	183,176
January 31, 1920	176,390	12,766	4,796	193,952
February	185,185	12,708	5,217	203,110
March 31	188,564	12,788	5,232	206,584
April	189,446	12,951	5,057	207,454
May 31	184,722	12,897	4,793	202,412
June 30	179,827	13,036	4,596	197,459
July	174,187	13,005	4,521	191,713
August	169,263	13,535	4,244	187,042
September 30	163,132	13,716	4,323	181,171
October	159,426	13,858	4,214	177,498
November	158,773	14,245	3,504	176,522

Cost and Profit on the Rand.

Compiled from official statistics published by the Transvaal Chamber of Mines. The profit available for dividends is about 65% of the working profit. Figures for yield and profit for 1919 based on par value of gold; subsequently gold premium included.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
July, 1919	2,134,668	27 10	21 9	6 0	611,118
August	2,036,128	28 5	22 11	5 5	551,203
September	2,019,109	28 6	22 10	5 7	560,979
October	2,108,698	28 3	22 6	5 10	612,841
November	1,933,526	28 8	23 5	5 5	521,472
December	1,845,088	28 8	25 6	3 10	354,098
Year 1919	24,043,638	[illegible] 7	22 11	5 6	6,605,509
January, 1920	2,038,092	[illegible]	24 2	10 2	1,036,859
February	1,869,180	35 1	28 3*	6 10*	644,571*
March	2,188,104	31 8	25 2	6 6	716,610
April	2,065,446	31 5	26 3	5 2	533,940
May	2,117,725	31 9	25 11	5 10	618,147
June	2,146,890	31 10	25 2	6 8	692,510
July	2,194,050	[illegible] 6	24 6	9 0	985,058
August	2,057,560	36 11	25 0	11 11	1,226,906
September	1,950,410	38 11	25 6	13 5	1,276,369
October	1,871,140	[illegible] 9	26 1	13 8	1,278,385

* Results affected by the back-pay disbursed in accordance with new wages agreement.

Production of Gold in Rhodesia and West Africa.

	Rhodesia 1919	Rhodesia 1920	West Africa 1919	West Africa 1920
	£	oz.	£	
January	211,917	43,428	104,063	
February	220,885	44,237	[illegible]	
March	225,808	[illegible]	112,543	
April	213,160	47,000	109,570	
May	218,057	46,266	100,827	No official returns published.
June	214,215	45,054	106,612	
July	214,919	46,208	102,467	
August	207,339	[illegible]	103,112	
September	223,719	45,471	100,401	
October	204,184	47,343	91,352	
November	186,462	46,782	98,322	
December	158,835		98,806	
Total	[illegible]	506,308	1,240,691	

Transvaal Gold Outputs.

	October Treated	October Yield	November Treated	November Yield
	Tons	Oz.	Tons	Oz.
Aurora West	9,400	£14,858*	9,100	£15,422*
Brakpan	56,000	[illegible]	52,600	22,946
City Deep	75,000	30,587	58,500	23,916
Cons. Langlaagte	39,200	£67,851*	40,100	£69,087*
Cons. Main Reef	47,000	16,500	44,200	[illegible]
Crown Mines	179,000	55,473	174,000	[illegible]
Durban Roodepoort Deep	[illegible]	7,331	23,600	7,827
East Rand P.M.	119,000	31,641	[illegible]	30,069
Ferreira Deep	30,700	[illegible]	30,200	10,490
Geduld	44,500	15,757	44,600	15,834
Geldenhuis Deep	45,300	12,473	46,200	12,487
Glynn's Lydenburg	3,060	£7,317*	3,265	[illegible]
Goch	12,900	£18,111*	14,000	[illegible]
Government G.M. Areas	135,000	£315,633*	130,500	£309,569*
Kleinfontein	43,800	12,458	43,600	12,397
Knight Central	24,400	6,507	22,450	5,932
Knights Deep				
Langlaagte Estate	41,500	£68,456*	38,400	£69,645*
Luipaard's Vlei	[illegible]	£21,781*	14,500	£20,567*
Meyer & Charlton	12,600	£48,733*	13,300	£46,426*
Modderfontein	94,000	47,358	93,000	45,325
Modderfontein B	55,000	28,705	53,500	27,691
Modderfontein Deep	42,600	21,927	42,700	22,564
Modderfontein East	26,600	10,916	26,100	11,447
New United	10,800	£14,746*	10,000	£14,215*
Nourse	44,700	13,852	41,600	12,824
Primrose	20,000	£23,884*	19,500	£24,373*
Princess Estate		553		641
Randfontein Central	104,500	£172,433*	101,000	£172,377*
Robinson	39,200	7,902	39,200	7,525
Robinson Deep	49,100	14,881	47,200	13,396
Roodepoort United	22,000	26,189	24,000	£26,801*
Rose Deep	47,500	12,067	45,800	11,363
Simmer & Jack	55,800	12,406	57,300	[illegible]
Springs	38,700	16,450	33,800	17,185
Sub Nigel	10,700	6,049	10,000	5,739
Transvaal G.M. Estates	17,430	£36,468*	15,650	£31,367*
Van Ryn	32,100	£51,203*	31,160	£55,009*
Van Ryn Deep	46,600	£142,895*	46,600	£90,024*
Village Deep	46,000	14,595	45,300	14,172
Village Main Reef	12,300	2,654		
West Rand Consolidated	30,800	£50,140*	30,300	£50,299*
Witwatersrand (Knights)	33,000	£55,471	32,000	£53,038*
Witwatersrand Deep	33,100	8,976	31,300	£50,489*
Wolhuter	33,500	8,398	32,500	8,435

* Output at £5. 17s. 6d. per oz.

West African Gold Outputs.

	October Treated	October Value	November Treated	November Value
	Tons	Oz.	Tons	Oz.
Abbontiakoon	6,401	£11,804*	5,492	£9,546*
Abosso	5,970	2,390	4,280	1,714
Akoko	—	—	210	158
Ashanti Goldfields	5,856	6,637	5,018	5,805
Obbuassi	694	£1,987*	660	£3,085*
Prestea Block A	9,629	£15,577*	8,670	£15,490*
Taquah	2,810	1,562	2,211	1,243

* At par

Rhodesian Gold Outputs.

	October Treated	October Oz.	November Treated	November Value
	Tons		Tons	
Falcon	15,362	2,983‡	15,013	2,735*
Gaika	3,858	1,285	3,933	1,333
Globe & Phoenix	5,722	7,277	5,759	7,875
London & Rhodesian	—	—	—	
Lonely Reef	5,400	5,344	5,350	5,298
Planet-Arcturus	5,400	2,460	5,650	2,985
Rezende	5,700	2,517	5,700	2,538
Rhodesia, Ltd.	834	[illegible]		
Rhodesia G.M. & I.	650	[illegible]	630	[illegible]
Shamva	51,150	£45,204§	45,050	£46,138§
Transvaal & Rhodesian	1,500	£5,055	1,500	£4,900

‡ Also 271 tons copper; * Also 251 tons copper.
§ Sold at 115s. per oz.

West Australian Gold Statistics.—Par Values.

	Reported for Export oz.	Delivered to Mint oz.	Total oz.	Total value £
October, 1919	586	64,987	65,573	278,535
November	1,171	64,823	65,994	280,323
December	831	27,334	28,165	162,575
January, 1920	836	25,670	26,506	112,590
February	1,928	49,453	51,381	218,251
March	—	54,020	54,020	229,461
April	835	56,256	57,091	242,506
May	227	50,976	51,203	217,495
June	502	56,679	57,181	242,638
July	—	48,341	48,341	205,340
August	167	54,258	54,425	231,185
September	141	54,940	55,081	233,963
October	174	53,801	53,975	229,275
November	128	54,729	54,857	233,017
December	321	53,595	53,916	229,057

Australian Gold Returns.

	Victoria.		Queensland.		New South Wales	
	1919	1920	1919	1920	1919	1920
	£	Oz.	£	Oz.	£	£
January	36,238	7,105	37,100	4,724	18,000	28,000
February	46,955	8,677	43,330	7,200	24,000	15,000
March	40,267	24,126	48,000	6,973	16,000	22,000
April	63,818	6,368	61,200	8,368	24,000	12,000
May	37,456	13,263	38,200	8,432	16,000	13,800
June	41,465	15,707	44,600	13,725	17,000	8,700
July	37,395	12,782	42,060	9,596	22,000	17,410
August	51,564	12,809	49,700	9,973	20,000	17,168
September	76,340	13,973	37,120	11,789	13,000	13,872
October	39,018	13,432	36,100	9,300	28,000	24,752
November	40,735	—	32,720	10,200	51,000	—
December	63,311	—	44,500	—	31,000	—
Total	575,260	127,141	514,630	100,201	280,000	172,702

Australasian Gold Outputs.

	October		November	
	Treated	Value	Treated	Value
	Tons	£	Tons	£
Associated G.M. (W.A.)	5,601	8,273	5,865	8,894
Blackwater (N.Z.)	1,042	1,411	2,685	3,804
Bullfinch (W.A.)	6,000	1,260‡	5,380	1,467‡
Cock's Pioneer (V.)	—	1,459*	—	—
Golden Horseshoe (W.A.)	10,560	4,916‡	10,608	4,717‡
Great Boulder Pro.(W.A.)	8,731	26,327	8,472	29,603
Ivanhoe (W.A.)	13,817	5,466‡	12,461	5,117‡
Kalgurli (W.A.)	3,681	7,702	3,038	3,945
Lake View & Star (W.A.)	9,892	12,881†	9,063	11,282†
Menzies Con. (W.A.)	1,500	2,828	1,570	2,906
Mount Boppy (N.S.W.)	6,002	7,240	5,636	7,070
Oroya Links (W.A.)	1,627	10,575	1,726	9,424
Progress (N.Z.)	—	538	—	—
Sons of Gwalia (W.A.)	12,996	16,065	10,373	13,302
South Kalgurli (W.A.)	7,238	2,917‡	7,058	12,643
Waihi (N.Z.)	12,706	4,007‡ 11,691§	13,103	3,576‡ 30,323§
Waihi Grand Junc'n (N.Z.)	—	—	7,760	2,394‡ 10,753§
Yuanmi (W.A.)	1,533	872‡	1,540	3,591

† Including royalties; ‡ Oz. gold; § Oz. silver; * Also 17 tons tin conc.

Miscellaneous Gold and Silver Outputs.

	October		November	
	Treated	Value	Treated	Value
	Tons	£	Tons	£
El Oro (Mexico)	33,000	216,000†	31,000	216,000†
Esperanza (Mexico)	—	10,408†‡	26,245	9,090†‡
Frontino & Bolivia (C'lbia)	2,650	7,464	2,470	7,562
Mexico El Oro (Mexico)	6,875	270,000†	11,000	164,320†
Mining Corp. of Canada	—	108,459*	—	
Oriental Cons. (Korea)	20,993	101,187	—	108,750†
Ouro Preto (Brazil)	5,600	2,044‖	6,000	2,008‖
Plymouth Cons. (Calif'rnia)	7,600	10,148	7,200	9,977
St. John del Rey (Brazil)	—	31,000	—	32,000
Santa Gertrudis (Mexico)	44,444	22,747‡	36,514	9,779‡
Sonora (Mexico)	1,252	6,292*		—
Tomboy (Colorado)	18,000	87,000†	16,000	85,000†

† U.S. Dollars. ‡ Profit, gold and silver. ‖ Oz. gold. * Oz. silver.

Production of Gold in India.

	1916	1917	1918	1919	1920
	oz.	oz.	oz.	oz.	oz.
January	45,214	44,718	41,420	38,184	39,073
February	43,121	42,566	40,787	36,834	38,872
March	43,702	44,617	41,719	38,317	38,760
April	44,797	43,726	41,504	38,248	37,307
May	45,055	42,901	40,889	38,608	38,191
June	44,842	42,924	41,264	38,359	37,864
July	45,146	42,273	40,229	38,549	37,129
August	45,361	42,591	40,496	37,850	37,375
September	45,255	43,207	40,088	36,813	35,497
October	45,061	43,041	39,472	37,138	35,023
November	45,247	42,915	36,984	39,628	34,522
December	48,276	44,883	40,149	42,643	34,919
Total	541,077	520,362	485,236	461,171	444,532

Indian Gold Outputs.

	November.		December.	
	Tons Treated	Fine Ounces	Tons Treated	Fine Ounces
Balaghat	3,200	2,320	3,300	2,564
Champion Reef	11,676	5,203	11,550	5,613
Mysore	18,169	12,249	17,699	12,049
North Anantapur	700	1,001	700	1,005
Nundydroog	8,656	5,300	8,837	5,222
Ooregum	12,800	8,449	12,900	8,466

Base Metal Outputs.

		Oct.	Nov.
Arizona Copper	Short tons copper	1,400	1,400
British Broken Hill	Tons lead conc.	—	—
	Tons zinc conc.	—	—
	Tons carbonate ore	—	—
Broken Hill Block 10	Tons lead conc.	—	—
	Tons zinc conc.	—	—
Burma Corp.	Tons refined lead	2,200	2,203
	Oz. refined silver	246,260	278,750
Fremantle Trading	Long tons lead	240	310
Hampden Cloncurry	Tons copper	552	505
	Oz. gold	335	324
Kafue Copper	Short tons copper	34	—
Mount Lyell	Tons copper	401	469
	Oz. silver	12,779	14,476
	Oz. gold	392	463
Mount Morgan	Tons copper	523	587
	Oz. gold	7,552	9,517
North Broken Hill	Tons lead	—	—
	Oz. silver	—	—
Pilbara Copper	Tons ore	114	97
Poderosa	Tons copper ore	480	250
Rhodesian Broken Hill	Tons lead	1,150	952
S'th American Copper	Tons copper ore ship'd.	1,750	—
Tanganyika	Long tons copper	1,224	—
Tolima	Tons silver-lead conc.	60	55
Zinc Corp.	Tons zinc conc.	—	—
	Tons lead conc.	—	—

Imports of Ores, Metals, etc., into United Kingdom.

		December.	Year 1920.
Iron Ore	Tons	528,628	6,500,911
Manganese Ore	Tons	47,345	452,613
Copper and Iron Pyrites	Tons	63,563	630,564
Copper Ore, Matte, and Precipitate	Tons	2,592	31,164
Copper Metal	Tons	9,201	104,930
Tin Concentrate	Tons	2,519	41,358
Tin Metal	Tons	2,410	28,749
Lead, Pig and Sheet	Tons	22,784	162,850
Zinc (Spelter)	Tons	7,217	109,367
Quicksilver	Lb.	445,006	2,682,016
Zinc Oxide	Tons	367	7,681
White Lead	Cwt.	9,757	669,491
Barytes	Cwt.	34,340	581,857
Phosphate	Tons	82,221	523,350
Sulphur	Tons	—	15,759
Borax	Cwt.	—	8,540
Other Boron Compounds	Tons	2,145	23,117
Nitrate of Soda	Cwt.	110,175	2,949,530
Nitrate of Potash	Cwt.	11,790	184,973
Petroleum:			
Crude	Gallons	993,315	4,180,128
Lamp Oils	Gallons	11,176,497	160,951,946
Motor Spirit	Gallons	12,381,806	207,739,144
Lubricating Oils	Gallons	11,739,132	105,914,877
Gas Oil	Gallons	1,547,732	53,564,775
Fuel Oil	Gallons	32,926,439	347,771,044
Total Petroleum	Gallons	70,768,408	880,207,568

OUTPUTS OF TIN MINING COMPANIES.
In Tons of Concentrate.

Nigeria	Sept. Tons	Oct. Tons	Nov. Tons
Associated Nigerian	20	[illegible]	20
[illegible]	—	—	
Bisichi	11	16	16
Bongwelli	1[illegible]	1½	1¼
Champion (Nigeria)	—	—	[illegible]
Dua	3	[illegible]	1½
Ex-Lands	35	33	35
Filani	8	5¼	5
Forum River	11	10	7[illegible]
Gold Coast Consolidated	5	3	[illegible]
Gurum River	15	15	15
Jantar	15	10	10
Jos	20½	22½	24¼
Kaduna	14¼	13	17½
Kaduna Prospectors	6¾	9¼	9
Kano	4½	5	5¼
Kura	–	12	–
Kwall		–	–
Lower Bisichi	9¼	8¾	8½
Lucky Chance	1	1	1
Minna	2½	3	2
Mongu	31	40	40
Naraguta	45	45	45
Naraguta Extended	24	23	15
Nigerian Consolidated	33¼	30	22½
Ninghi	4½	6	5½
N. N. Bauchi	53	55	55
Offin River		-	–
Rayfield	35	35	35
Ropp	92	168	115
Rukuba	3½	5½	4
South Bukeru	8½	13	15
Sybu	1½	1¼	–
Tin Fields	8½	8	4
Yarde Kerri	4	5	4
Federated Malay States:			
Chenderiang	79*	–	–
Gopeng	60	72	72
Idris Hydraulic	17¾	18	19¼
Ipoh	12	13½	13
Kamunting	106*	–	–
Kinta	26	32¾	32¾
Lahat	53½	59½	59½
Malayan Tin	68½	80½	78¾
Pahang	183	178½	166
Rambutan	13	15	16½
Sungei Besi	30	30	31
Tekka	36	30	30
Tekka-Taiping	39	39	31
Tronoh	37	49½	38
Cornwall			
East Pool	68*	69⅛†	74†
Geevor	-	—	—
Grenville		—	—
South Crofty	54†	55†	60¾†
Other Countries:			
Aramayo Francke (Bolivia)	180	—	
Berenguela (Bolivia)	[illegible]0	29	27
Briseis (Tasmania)	21	20	23
Deebook (Siam)	18	19½	19½
Leeuwpoort (Transvaal)	265*		—
[illegible] (Swaziland)	21*		—
Mawchi (Burma)	70*		—
Porco (Bolivia)	5	—	—
Renong (Siam)	59½	6[illegible]	93½
Rooiberg Minerals (Transvaal)	50	50	15
Siamese Tin (Siam)	53½	60½	63¼
Tongkah Harbour (Siam)	85	68	76
Zaaiplaats (Transvaal)	30	28	28

* Three months. † Tin and wolfram.

NIGERIAN TIN PRODUCTION.

In long tons of concentrate of unspecified content.

Note. These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual outputs.

	1915	1916	1917	1918	1919	1920
	Tons	Tons	Tons	Tons	Tons	Tons
January	417	531	667	678	613	547
February	358	528	646	668	623	477
March	418	547	655	707	606	505
April	444	486	555	584	546	467
May	357	536	509	525	483	[illegible]
June	373	510	473	492	484	435
July	455	506	479	545	481	484
August	438	498	551	571	616	447
September	442	535	538	520	561	528
October	511	584	578	491	625	628
November	467	679	621	472	536	544
December	533	654	655	518	511	—
Total	5,213	6,594	6,927	6,771	6,685	5,445

PRODUCTION OF TIN IN FEDERATED MALAY STATES.

Estimated at 70% of Concentrate shipped to Smelters.
Long Tons.

	1916	1917	1918	1919	1920
	Tons	Tons	Tons	Tons	Tons
January	4,316	3,558	3,149	3,765	4,265
February	3,372	2,755	3,191	2,673	3,014
March	3,696	3,286	2,608	2,819	2,770
April	3,177	3,251	3,308	2,855	[illegible],606
May	3,729	3,413	3,332	3,404	2,741
June	3,435	3,489	2,950	2,873	2,940
July	3,517	3,253	3,373	3,756	2,824
August	3,732	3,413	3,259	2,955	2,786
September	3,636	3,154	3,166	3,161	2,734
October	3,681	3,436	2,870	3,221	2,837
November	3,635	3,300	3,131	2,972	2,573
December	3,945	3,525	3,023	2,413	—
	43,871	39,833	37,370	36,867	32,090

TOTAL SALES OF TIN CONCENTRATE AT REDRUTH TICKETINGS.

	Long tons	Value	Average
August 25, 1919	130½	£18,297	£140 4 3
September 8	115½	£16,588	£143 12 6
September 22	135½	£19,557	£144 6 9
October 8	72	£10,867	£150 18 7
October 20	32	£5,093	£159 3 2
November 3	34½	£5,235	£151 15 0
November 17	39	£6,161	£157 19 9
December 1	38	£5,905	£155 8 3
December 15	29	£5,133	£176 10 0
December 31	14¾	£2,884	£195 10 10
Total and Average, 1919	2,858	£366,569	£128 5 0
January 12, 1920	31	£6,243	£201 8 0
January 26	51¾	£10,574	£204 6 10
February 9	37½	£7,880	£210 2 8
February 23	53¾	£12,120	£225 10 0
March 8	18	£4,038	£224 7 7
March 22	44	£8,286	£188 6 8
April 6	44½	£[illegible]	£188 0 5
April 19	33½	£6,375	£190 6 0
May 3	61½	£11,641	£189 5 9
May 17	44	£6,151	£139 16 0
May 31	10	£1,578	£157 16 0
June 14	24¾	£3,278	£132 9 3
June 28	14½	£1,932	£133 4 10
July 12	43¾	£6,133	£140 4 0
July 26	10½	£1,643	£156 10 0
August 9	10½	£1,664	£158 10 0
August 23	27¼	£4,022	£147 12 0
September 6	19	£2,563	£134 18 6
September 20	10	£1,552	£155 5 0
October 4	9	£1,359	£151 0 7
October 18	39½	£5,225	£132 5 11
November 1	9	£1,329	£147 14 5
November 15	4½	£597	£132 17 6
November 29	8½	£965	£113 12 0
December 13	8½	£981	£115 8 6
December 28	8½	£946	£11[illegible] 5 10

On December 13, Tincroft sold 8½ tons, and on December 28 a similar amount.

Stocks of Tin.

Reported by A. Strauss & Co. Long Tons.

	Oct. 31	Nov. 30	Dec. 31
Straits and Australian Spot	1,043	1,944	2,170
Ditto, Landing and in Transit	556	620	1,138
Other Standard, Spot and Landing	3,261	2,743	3,855
Straits, Afloat	2,154	1,955	1,183
Australian, Afloat	179	203	250
Banca, in Holland	2,143	2,966	3,511
Ditto, Afloat	1,222	1,095	278
Billiton, Spot	—	721	755
Billiton, Afloat	230	295	264
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	100	300	485
Total Afloat for United States	5,363	3,257	1,734
Stock in America	3,191	2,966	2,856
Total	19,442	19,065	18,479

Shipments, Imports, Supply, and Consumption of Tin.

Reported by A. Strauss & Co. Long tons.

	Oct.	Nov.	Dec.
Shipments from:			
Straits to U.K.	1,470	1,505	915
Straits to America	1,770	825	825
Straits to Continent	100	300	485
Straits to Other Places	165	199	225
Australia to U.K.	350	350	250
U.K. to America	225	175	150
Imports of Bolivian Tin into Europe	1,117	2,172	251
Supply:			
Straits	3,340	2,630	2,225
Australian	350	350	250
Billiton	542	482	—
Banca	1,148	1,154	250
Standard	1,305	475	1,500
Total	6,685	5,091	4,225
Consumption:			
U K. Deliveries	1,670	1,607	1,518
Dutch „	126	215	366
American „	3,465	3,420	2,580
Straits, Banca & Billiton, Continental Ports, etc.	308	226	347
Total	5,569	5,468	4,811

Dividends Declared by Mining Companies.

Date	Company	Par Value of Shares	Amount of Dividend
Dec. 22	Anglo-American Corp'n of South Africa		5% less tax
Dec. 21	Apex Mines	10s.	7½d. less tax
Jan. 7	Champion Reef	2s. 6d.	4d. less tax
Dec. 17	De Beers Consolidated	Pref.	20% less tax
		Def.	20% less tax
Dec. 21	Gopeng Consolidated		9d. less tax
Dec. 22	Leeuwpoort (African Farms) Tin		10%
Dec. 22	McCreedy Tin		10%
Dec. 17	New Era		20% less tax
Dec. 27	Ouro Preto	Pref. £1.	1s. less tax
Dec. 21	Rand Mines	5s.	4s. 3d. less tax
Dec. 17	Rand Selection Corporation		17½% less tax
Dec. 14	Rezende		20% less tax
Jan. 4	Tekka	£1.	4½% less tax
Dec. 18	Tongkah Harbour Tin Dredging		2s.

PRICES OF CHEMICALS. January 7.

These quotations are not absolute; they vary according to quantities required and contracts running.

		£	s.	d.
Alum	per ton	19	0	0
Alumina, Sulphate of	„	16	0	0
Ammonia, Anhydrous	per lb.		2	6
„ 0.880 solution	per ton	46	0	0
„ Carbonate	per lb.			6½
„ Chloride of, grey	per ton	54	0	0
„ „ „ pure	per cwt.	5	10	0
„ Nitrate of	per ton	50	0	0
„ Phosphate of	„	95	0	0
„ Sulphate of	„	24	0	0
Antimony Sulphide, Golden	per lb.		1	6
Arsenic, White	per ton	65	0	0
Barium Sulphate	„	10	0	0
Bisulphate of Carbon	„	55	0	0
Bleaching Powder, 35% Cl.	„	19	0	0
Borax	„	41	0	0
Copper, Sulphate of	„	38	0	0
Cyanide of Sodium, 100%	per lb.		1	0
Hydrofluoric Acid	„			7½
Iodine	per oz.		1	0
Iron, Sulphate of	per ton	4	0	0
Lead, Acetate of, white	„	58	0	0
„ Nitrate of	„	55	0	0
„ Oxide of, Litharge	„	50	0	0
„ White	„	64	0	0
Lime, Acetate, brown	„	15	0	0
„ „ grey 80%	„	22	0	0
Magnesite, Calcined	„	22	0	0
Magnesium, Chloride	„	13	0	0
„ Sulphate	„	10	0	0
Methylated Spirit 64° Industrial	per gal.		7	4
Phosphoric Acid	per lb.		1	6
Potassium Bichromate	per lb.		1	4
„ Carbonate 85%	per ton	65	0	0
„ Chlorate	per lb.		0	8
„ Chloride 80%	per ton	30	0	0
„ Hydrate (Caustic) 90%	„	70	0	0
„ Nitrate	„	50	0	0
„ Permanganate	per lb		3	0
„ Prussiate, Yellow	„		1	7
„ Sulphate, 90%	per ton	38	0	0
Sodium Metal	per lb.		1	3
„ Acetate	per ton	47	0	0
„ Arsenate 45%	„	55	0	0
„ Bicarbonate	„	9	0	0
„ Bichromate	per lb.			11
„ Carbonate (Soda Ash)	per ton	16	0	0
„ „ (Crystals)	„	7	0	0
„ Chlorate	per lb.			5½
„ Hydrate, 76%	per ton	28	0	0
„ Hyposulphite	„	23	0	0
„ Nitrate, 95%	„	24	0	0
„ Phosphate	„	32	0	0
„ Prussiate	per lb.			11
„ Silicate	per ton	11	0	0
„ Sulphate (Salt-cake)	„	9	0	0
„ „ (Glauber's Salts)	„	10	0	0
„ Sulphide	„	36	0	0
Sulphur, Roll	„	17	0	0
„ Flowers	„	17	0	0
Sulphuric Acid, Fuming, 65°	„	24	0	0
„ „ free from Arsenic, 144	„	6	5	0
Superphosphate of Lime, 18%	„	6	10	0
Tartaric Acid	per lb.		2	2
Tin Crystals	„		1	9
Zinc Chloride	per ton	27	0	0
Zinc Sulphate	„	22	0	0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS:	Jan. 7, 1920 £ s. d.	Jan. 7, 1921 £ s. d.
RAND:		
Brakpan	[illegible] 1 3	3 0 0
Central Mining (£8)	11 10 0	[illegible] 0
City & Suburban (£4)	9 0	6 6
City Deep	[illegible]	6
Consolidated Gold Fields	1 18 9	18 9
Consolidated Langlaagte	1 6 [illegible]	18 0
Consolidated Main Reef	16 [illegible]	13 6
Consolidated Mines Selection (10s.)	1 18 0	18 6
Crown Mines (10s.)	3 16 3	2 7 6
Daggafontein	1 2 0	8 6
Durban Roodepoort Deep	13 0	3 9
East Rand Proprietary	11 6	6 6
Ferreira Deep	12 6	8 9
Geduld	2 16 3	2 8 9
Geldenhuis Deep	15 0	8 3
Gov't Gold Mining Areas	5 2 6	4 5 0
Heriot	11 6	9 3
Johannesburg Consolidated	1 14 6	1 4 6
Jupiter	7 6	2 0
Kleinfontein	14 6	7 6
Knight Central	7 0	5 6
Knights Deep	12 0	9 0
Langlaagte Estate	1 0 0	13 6
Meyer & Charlton	5 2 6	4 12 6
Modderfontein (£4)	4 10 0	3 12 6
Modderfontein B (5s.)	9 8 9	1 10 0‡
Modderfontein Deep (5s.)	2 15 0	2 3 9
Modderfontein East	1 12 6	1 0 0
New State Areas	1 12 6	1 5 0
Nourse	17 0	9 0
Rand Mines (5s.)	4 0 0	2 11 3
Rand Selection Corporation	5 7 6	3 0 0
Randfontein Central	1 0 6	11 0
Robinson (£5)	14 6	9 0
Robinson Deep A (1s.)	1 3 9	11 3
Rose Deep	1 5 0	16 9
Simmer & Jack	6 6	3 0
Simmer Deep	3 3	
Springs	3 2 6	1 16 3
Sub Nigel	1 2 6	13 9
Union Corporation (12s. 6d.)	1 3 0	16 6
Van Ryn	1 1 3	12 6
Van Ryn Deep	5 3 9	3 17 6
Village Deep	1 6 3	8 9
Village Main Reef	17 6	5 3
West Springs	7 6	16 3
Witwatersrand (Knight's)	1 1 3	13 9
Witwatersrand Deep	11 6	7 0
Wolhuter	5 9	3 9
OTHER TRANSVAAL GOLD MINES:		
Glynn's Lydenburg	16 3	10 0
Transvaal Gold Mining Estates	18 9	8 6
DIAMONDS IN SOUTH AFRICA:		
De Beers Deferred (£2 10s.)	32 5 0	13 5 0
Jagersfontein	6 17 6	3 0 0
Premier Deferred (2s. 6d.)	13 0 0	5 15 0
RHODESIA:		
Cam & Motor	11 0	8 0
Chartered British South Africa	1 0 6	15 0
Falcon	17 0	10 0
Gaika*	17 6	11 0
Globe & Phœnix (5s.)	16 0	19 6
Lonely Reef	3 2 6	2 10 0
Rezende	4 [illegible] 0	2 15 0
Shamva	2 3 9	1 11 3
Willoughby's (10s.)	7 3	5 3
WEST AFRICA:		
Abbontiakoon (10s.)	5 6	2 9
Abosso	12 6	9 0
Ashanti (4s.)	1 4 0	15 3
Prestea Block A	5 6	2 0
Taquah	17 6	10 0
WEST AUSTRALIA:		
Associated Gold Mines	3 6	3 0
Associated Northern Blocks	[illegible]	3 0
Bullfinch	[illegible]	1 6
Golden Horse Shoe (£5)	1 6 [illegible]	15 0
Great Boulder Proprietary (2s.)	9 [illegible]	5 3
Great Fingall (10s).	1 6	1 6
Hampton Properties	1 11 3	7 6
Ivanhoe (£5)	1 18 9	18 9
Kalgurli	1 0 0	11 3
Lake View Investment (10s.)	1 3 [illegible]	11 3
Sons of Gwalia	10 [illegible]	5 6
South Kalgurli (10s.)	5 6	6 0

GOLD, SILVER, *cont.*	Jan. 7, 1920 £ s. d.	Jan. 7, 1921 £ s. d.
OTHERS IN AUSTRALASIA:		
Blackwater, New Zealand	8 9	8 9
Consolidated G. F. of New Zealand	3 [illegible]	[illegible] 9
Mount Boppy, N.S.W. (10s.)	6 0	2 6
Progress, New Zealand	1 9	1 9
Talisman, New Zealand	8 9	6 6
Waihi, New Zealand	2 7 6	1 5 [illegible]
Waihi Grand Junction, New Z'lnd	12 6	8 9
AMERICA:		
Buena Tierra, Mexico	15 0	6 [illegible]
Camp Bird, Colorado	1 0 6	7 6
El Oro, Mexico	15 6	11 6
Esperanza, Mexico	15 6	1 6 [illegible]
Frontino & Bolivia, Colombia	12 6	8 0
Le Roi No. 2 (£5), British Columbia	11 [illegible]	5 0
Mexico Mines of El Oro, Mexico	7 0 0	5 10 0
Nechi (Pref. 10s.), Colombia	12 0	7 6
Oroville Dredging, Colombia	1 7 6	1 2 6
Plymouth Consolidated, California	1 [illegible] 9	17 6
St. John del Rey, Brazil	16 9	15 6
Santa Gertrudis, Mexico	1 12 6	12 6
Tomboy, Colorado	13 9	7 6
RUSSIA:		
Lena Goldfields	1 7 6	12 6
Orsk Priority	12 6	5 0
INDIA:		
Balaghat (10s.)	6 3	7 6
Champion Reef (2s. 6d.)	5 0	2 9
Mysore (10s.)	1 1 3	12 6
North Anantapur	4 3	2 6
Nundydroog (10s.)	14 6	4 9
Ooregum (10s.)	16 9	11 3

COPPER:

	Jan. 7, 1920 £ s. d.	Jan. 7, 1921 £ s. d.
Arizona Copper (5s.), Arizona	2 2 6	1 10 0
Cape Copper (£2), Cape and India.	2 [illegible] 6	15 0
Esperanza, Spain	5 9	5 0
Hampden Cloncurry, Queensland	1 1 3	5 0
Mason & Barry, Portugal	2 5 0	1 10 0
Messina (5s.), Transvaal	5 0	4 0
Mount Elliott (£5), Queensland	4 0 0	10 0
Mount Lyell, Tasmania	1 6 0	16 3
Mount Morgan, Queensland	1 3 9	12 6
Mount Oxide, Queensland	8 0	—
Namaqua (£2), Cape Province	1 12 6	1 5 0
Rio Tinto (£5), Spain	49 10 0	25 0 0
Russo-Asiatic Consd., Russia	—	9 3
Sissert, Russia	17 6	11 3
Spassky, Russia	1 5 0	12 6
Tanganyika, Congo and Rhodesia	2 18 9	1 6 3

LEAD-ZINC:

	Jan. 7, 1920 £ s. d.	Jan. 7, 1921 £ s. d.
BROKEN HILL:		
Amalgamated Zinc	1 6 9	17 6
British Broken Hill	2 6 3	1 1 [illegible]
Broken Hill Proprietary	2 12 6	2 3 9
Broken Hill Block 10 (£10)	1 5 0	15 0
Broken Hill North	2 17 6	1 10 0
Broken Hill South	2 16 [illegible]	1 12 6
Sulphide Corporation (15s.)	1 3 0	12 6
Zinc Corporation (10s.)	1 2 0	12 6
ASIA:		
Burma Corporation (10 rupees)	14 0 0	8 6†
Russian Mining	12 6	7 6
RHODESIA:		
Rhodesia Broken Hill (5s.)	17 6	8 3

TIN:

	Jan. 7, 1920 £ s. d.	Jan. 7, 1921 £ s. d.
Aramayo Francke, Bolivia	4 12 6	2 15 0
Bisichi, Nigeria	16 3	6 3
Briseis, Tasmania	4 6	4 0
Dolcoath, Cornwall	8 5	6
East Pool (5s.) Cornwall	18 3	7 0
Ex-Lands Nigeria (2s.), Nigeria	3 3	2 3
Geevor (10s.) Cornwall	1 4 0	3 9
Gopeng, Malay	2 0 0	1 10 0
Ipoh Dredging, Malay	18 6	13 9
Kamunting, Malaya	2 6 3	2 10 0
Kinta, Malaya	2 15 0	1 12 6
Malayan Tin Dredging, Malay	2 8 9	1 8 9
Mongu (10s.), Nigeria	1 9 0	13 9
Naraguta, Nigeria	17 6	10 0
N. N. Bauchi, Nigeria (10s.)	9 0	1 9
Pahang Consolidated (5s.), Malay.	15 0	[illegible] 3
Rayfield, Nigeria	15 0	4 0
Renong Dredging, Siam	2 15 6	1 13 9
Ropp (4s.), Nigeria	1 12 0	7 0
Siamese Tin, Siam	3 15 0	2 10 0
South Crofty (5s.), Cornwall	19 0	7 9
Tehidy Minerals, Cornwall	1 6 3	10 0
Tekka, Malay	4 12 6	1 0 0§
Tekka-Taiping Malay	6 10 0	1 [illegible] 9§
Tronoh, Malay	2 12 6	1 6 3

‡ £1 shares split into 4 of 5s each. † 10-rupee shares of Indian Co. § New shares. * New shares 5s. paid.

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

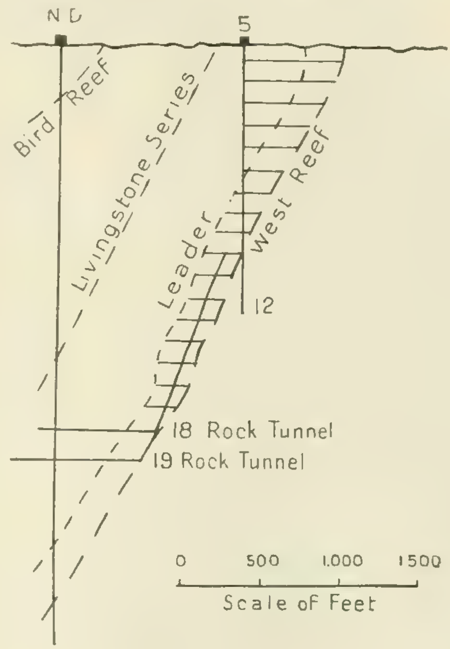
In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also reviews of new books, and abstracts of the yearly reports of mining companies.

NEW DEVELOPMENT METHODS AT RANDFONTEIN CENTRAL.

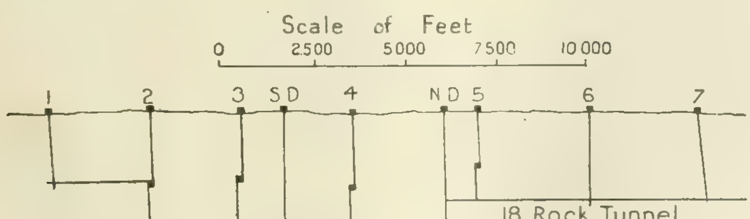
The November *Journal* of the South African Institution of Engineers contains a paper by G. H. Beatty on the new shafts and development methods at the Randfontein Central. These new methods were adopted after the acquirement of control by Barnatos from Sir J. B. Robinson.

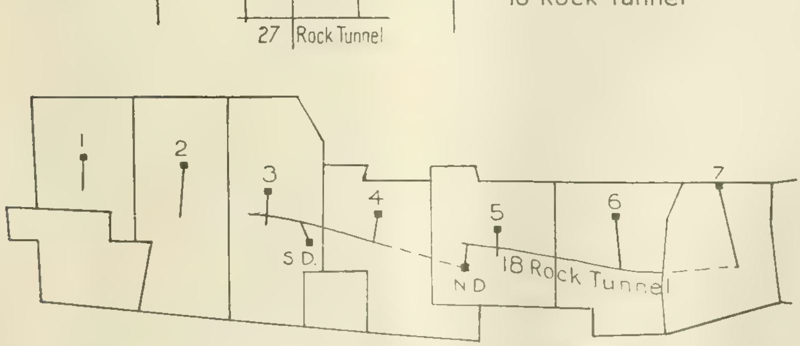
The portion of the Randfontein group of mines affected by the new lay-out consists of seven sections—numbered 1 to 7—from south to north on the strike of the reef series. Mining operations are being carried on in sections Nos. 2 to 7, along a strike of 17,000 feet. With the old lay-out, hoisting and pumping were conducted in all sections through ten shafts, namely, the Nos. 1, 6, and 7 main inclines, No. 2 sub-incline, and Nos. 3, 4, and 5 main verticals and sub-inclines. Until 1918 the No. 7 section was served by a main compound shaft and sub-incline. In that year the sub-incline was connected to the surface, and the compound shaft was cut out. The ten shafts were served by 19 hoists, and employed 54 engine drivers, 54 skipmen, 20 banksmen, and 30 shaft timbermen. The average monthly tonnage hoisted during the year 1919 was 103,000 tons, at a hoisting cost of 2·363s. per ton, from an average depth of 2,300 ft. In September, 1917, a start was made upon the sinking of two new verticals, known as the North and South Deep shafts, the object being to cut out all nine shafts in sections No. 1 to 6.

There are two reefs, 200 ft. apart horizontally, with a very even strike roughly north and south, and a regular dip averaging 65°. Dislocations are rare, and the few faults and dykes in evidence are not of much importance. The gold is evenly distributed, and about



Cross-Section of Reefs.





Sketch Plan of Shafts and Rock Tunnels.

85% of the ore developed is stoped. With the exception of the steep dip, these conditions are favourable, but, on the other hand, the reef channel is very thin, the hanging and foot-walls are difficult to support, and the present workings are subject to great pressure and movement, due to depth and the fact that practically all the ore above them has been stoped out and no support provided.

The design of the new shafts has already been the subject of a paper read by W. L. White and published in the *Journal* in February, 1919. (See the MAGAZINE for April, 1919.) They are designed and situated so as to serve an ultimate depth of 5,000 ft. They are placed in a position to intersect the reefs midway in the area between the present lowest workings and that depth. With a dip as high as 65° no great amount of cross-cutting is necessary from the shafts to the reefs, even on the top and bottom levels

Under the old shaft lay-out, five inclines were being sunk to exploit the area, namely, the No. 6 main incline and Nos. 5, 4, 3, and 2 sub-inclines. They were very difficult to sink, and progress was painfully slow owing to the awkward dip and delays caused by breakdowns in the pumping and hoisting plants.

The old method of development was the usual practice on the Rand, and consisted of cross-cuts from the shaft stations to the reefs, reef drives, and connections between drives at intervals. The vertical distance between drives was about 120 ft. This method proved costly, inadequate, and totally unsuited to the local conditions, for the following reasons: (*a*) Limited speed and high cost or driving on reef, because when a drive had advanced some distance the operations behind it retarded its progress. Almost immediately stoping commenced it became necessary to timber the drives. Pillars left above the level were useless and dangerous, and consequently a quantity of rock was always broken directly on to the level. This resulted in constant injury to the water and air supply pipes, difficulty in feeding the machines, and delay in cleaning out the development end. (*b*) Cost of supporting drives. With several stopes working above and below any drive, it became necessary to close-timber it practically from end to end, and the timber had to be renewed several times per annum. (*c*) Cost of tramming. The track was subject to injury through blasting operations and falling rock. As before mentioned, the dip is 65°, and with sufficient foot-wall cut away to support the track, the foot-wall of the upper stope became troublesome, and the stoping width above the drive difficult to control; further, the development rock value was reduced to practically nothing. With insufficient foot-wall cut away the track sagged immediately stoping commenced below the level. Owing to pressure, no regular grade could be kept on the track, and in stoped areas the track became a switchback. Rock from inside stopes had to be trammed through congested drives and past numerous box-holes, through which water and fines were falling, with resulting derailments. (*d*) Limited output from any one drive in a given time, due to reasons given in (*c*) and (*f*). (*e*) Length of time each drive had to be kept in commission, due to (*d*). (*f*) No mechanical means of transport was possible through the reef drives. (*g*) Mine water could not be kept on the level on which it was struck or used, and found its way to the lowest stoping level, becoming very muddy in its progress. (*h*) The cost of support and tramming increased with the age of the level, and toward the end of its life, the inside stopes —probably one or two faces only were working—had to bear the whole cost of upkeep. Unless they were rich they were unpayable and abandoned. (*j*) It was difficult to control air currents and the ventilation was unsatisfactory in places. (*k*) Loss of compressed air in friction and leakages; 140,000 ft. of air pipe was in commission in the reef drives, all of it liable to damage from many sources. (*l*) The workable length of a drive on reef was limited, and a shaft could serve a limited strike only.

The new method introduced is as follows: A heading termed a "rock tunnel," size 8 ft. by 8 ft., is driven from 30 to 50 ft. in the foot-wall of the lower reef, and cross-cuts are driven to the reefs at intervals of 500 ft. The levels are connected by means of winzes and rises from the intersections of reefs and cross-cuts. Reef drives are driven at leisure as the stope-faces advance. The distance between levels is 174 ft. vertically, giving 200 ft. to 210 ft. backs. The rock tunnels are provided with either 10 ton electric locomotives, of the overhead wire type, or smaller battery locomotives. Sidings for ten 30 cwt. cars are provided at each cross cut.

The advantages of this system are as follows: (*a*) Ore can be developed rapidly, as there is nothing to hinder the rapid advancement of the rock tunnel. (*b*) Each stope-face has an independent drive, there is no tramming past box-holes or through congested drives, and the average length of hand tram to the rock tunnels is 270 ft. only. When the stope-face is worked out, it is reclaimed, washed, and abandoned, together with its drive. (*c*) Given adequate means of transport, the rock tunnels can easily handle the rock broken in the stopes feeding them; their life is, therefore, determined by the rate at which they can be driven, and the rate of exhaustion in the stopes. Concentration is thus possible in a high degree, and the life of a level and the number of levels in commission are reduced to a minimum. (*d*) The main air and water supply pipes are situated in the rock tunnels, and out of harm's way. (*e*) Mine water is led to the rock tunnels, which are provided with concreted drains. (*f*) There is no difficulty in controlling air currents, and ventilation is improved. (*g*) The rock tunnels can be of great length, with very little disadvantage. Transport of rock, material, or men through them presents no difficulty or undue expense. The rock tunnels going north from the North Deep shaft will be 6,000 ft. long. Locomotives travelling at eight miles per hour bring the most distant workings within nine minutes of the shaft. (*h*) It is evident that the method has a beneficial effect upon the grade of the ore crushed. The value of development rock from main drives driven on reef averages only about 2·5 dwt. per ton, even when the reef is carried in the correct position in the drives. But with a steep reef a degree of accuracy is necessary which is not obtainable under present-day conditions, with the result that an unnecessary amount of waste is broken at times. Flaking commences as soon as stoping is in full swing and weight thrown upon the lengths of drive between stope-faces, and the drives are constantly increasing in size until finally stoped out. It is probable that the rock broken in drives, plus subsequent additions of waste, averages under 2 dwt. per ton. The new shafts are provided with waste bins on every level, and the waste broken in the rock tunnels and cross-cuts is trammed and hoisted as waste. The waste broken in the reef drives is easily controlled and kept at a minimum; in most cases the reef drive is no more than a ledge, wide enough to support a 2 ft. track, cut in the foot-wall.

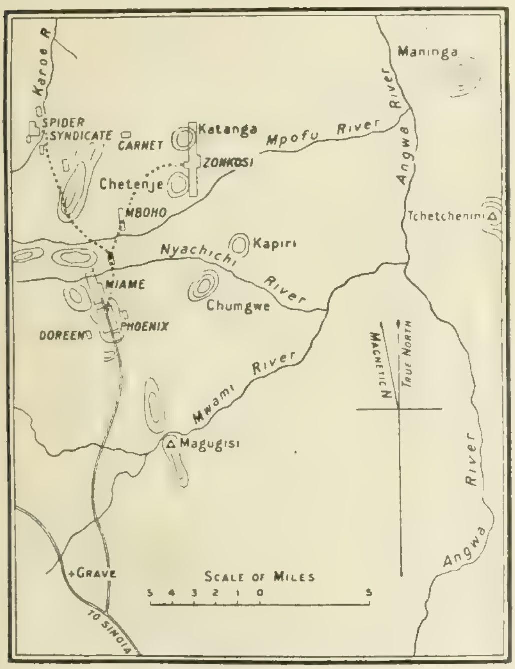
The method eliminates the working defects and limitations of the old system, and permits of two shafts serving a strike of 14,000 ft. for rock concentration and hoisting purposes, and an additional 6,000 ft. for drainage. Further, it greatly increases the tonnage that a

given area can produce in a given time. The area in question, Nos. 2 to 6 sections inclusive, may be called upon to produce 1,700,000 tons per year. To develop that quantity of ore it will be necessary to drive 14,000 ft. of rock tunnel annually, and to break and handle the tonnage it will be necessary to have 28,000 ft. of rock tunnel in full commission. Not more than four levels will be in commission at one time; probably two will be in certain stages of exhaustion, one in full commission, and one opening up.

It may appear that the points of attack for development purposes are insufficient for such a large area. Roughly speaking, the strike is divided by the shafts into stretches of 4,000 ft. at the southern end, 4,500 ft. between shafts, and 5,500 ft. at the northern end. Thus, as the middle portion will be attacked from two ends, there will be four points of attack until the middle portion is developed, and two afterwards, or, say, an average of three over the development life of the level. If development work is confined to the single-shift basis, it will be necessary to have twelve ends working, or four levels in course of development.

MICA DEPOSITS IN LOMAGUNDI, RHODESIA.

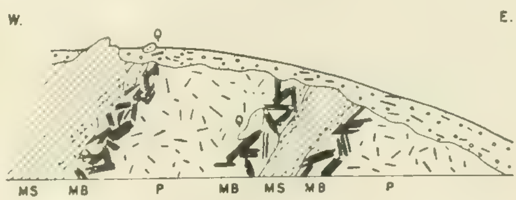
A report has been issued by the Rhodesia Geological Survey, written by the Government Geologist, H. B. Maufe, on the mica deposits, recently developed, on the western flanks of the Angwa river basin in the Lomagundi District of Rhodesia. The majority of the claims are situated between the Mwami and Mkwichi rivers, tributaries to the left bank of the Angwa river. The area over which the mica claims are scattered measures more than 40 square miles, but the limits of the deposits are not known. The deposits are only a few miles east of the probable route of the proposed Sinoia-Kafue Railway, and is about 64 miles from present rail-head at Sinoia.



Sketch Map of Mica District.

The country-rock is a well-foliated mica schist remarkably uniform in composition. On the rough edges of the rock glassy quartz in grains and small lenticles may be seen lying between the mica scales, but it seldom seems to form as much as half the rock. The chief variation from the mica schist is due to the incoming of quartzite or quartz schist bands. These consist of grey, micaceous quartzite from a fraction of an inch to several feet thick. Usually a number of bands of quartzite are separated by bands of mica-schist, and in places the alternations are so rapid that the rock might be described as a striped schist. Some bands contain a little biotite in addition to muscovite. A fine-grained grey porphyritic biotite granite crops out at the northern end of the Miame claims. As is so frequently the case, a stream follows the contact between granite and schist, and the granite was not actually seen to be intrusive into the schist. A grey felsite and a small outcrop of diorite similar to that seen in the Angwa river on Romsey farm were noticed in the small stream running into the Karoe river.

Pegmatite dykes contain all the merchantable mica. They commonly trend in a direction a few degrees west of north, but cannot often be followed for as much as 100 yards without setting off to the east or to the west. They vary in width from a few inches to 10 or 15 yards, and over much of the field they dip to the west at high angles. In the north-western part of the field called Dounka, situated around the Karoe (north) river, the dykes dip east at a high angle and are on the average narrower than elsewhere. The mica books occur in the dykes in a remarkably regular manner, which assists considerably prospecting and mining. The books occur in a belt or in a succession of lenticles against the mica schist walls, and usually on both sides of a dyke, as shown. Otherwise the dykes present the many variations of composition so characteristic of pegmatites. The commonest variety of pegmatite is one consisting almost entirely of felspar, the quartz occurring inconspicuously in glassy grey blebs scattered through the felspar, which is itself decomposed to a pinkish, buff, or white earth. This kind of rock usually forms the central portion of a dyke. In some instances it has scattered regularly through it books of mica lying at all angles. The books are large, but very thin. The mica is stained a dark colour and does not yield a marketable grade. In portions of some dykes, and usually near the walls, the quartz becomes more abundant than the felspar and forms lenticles or blows. These quartz blows are occasionally free from felspar, but contain numerous books of mica an inch or two in length. This variety is known on the field as greisen. It usually lies close beside, or is mixed with, the pockets of workable mica. Since this greisen resists decomposition and disintegration, it forms blocks at the surface, and is frequently



Pegmatite Dykes with Books of Mica.

the only indication of a pegmatite dyke. In prospecting greisen may be taken as an indication of a possible mica-bearing dyke beneath.

The mica is wholly muscovite, chemically a hydrated silicate of aluminium and potassium. It is usually either of a ruby or of a bottle-green colour, though some clouded silvery mica has been found. The statement that marketable biotite and phlogopite have been found is not substantiated. The native name for the mica is "datsi." The books of mica occur in a band or in a series of lenticles on each wall of a pegmatite dyke, the books lying at all angles, but often touching one another and even being closely packed. The band or lenticle is in places close to the wall of mica schist country-rock, in others separated from it by a few inches of pegmatite. Here and there a dyke is seen with only one band, but this is unusual, except in the case of the narrower dykes. Inclusions or horses of mica schist country-rock are very common in the dykes, and it is usual to find a zone of mica books completely surrounding the horse, which is thus a structure not unwelcome to the mica miner. The books vary in size from 4 to 5 in. in length to as many feet, the majority probably being between 6 and 18 in. They are seldom more than 6 in. thick, and frequently half that. Much of the mica is stained, near the surface deeply stained, but mining seems to show that staining diminishes 10 to 15 ft. down, and the mica becomes slightly stained, spotted, or clear.

All work is open-cut, and at the time of Mr. Maufe's visit had not gone below a depth of about 35 ft. Much of the work is done by pick and shovel, the felspar of the pegmatite being decomposed to a clay and therefore easy to work. When blasting has to be resorted to, either 30% or farmer's dynamite is used for loosening the rock without shattering the books. The pegmatite dykes are on some claims so closely placed that it is economical to take out together the foot-wall band of mica, the intervening strip of mica-schist country-rock, and the hanging-wall band of mica in the next dyke. In other cases the two bands belonging to the one dyke are worked together, or each band is separately worked. The books commonly split up on being taken out into slabs about ½ in. thick. These slabs are taken to the dressing ground, and first split up with the aid of a knife into sheets about $\frac{1}{32}$ in. thick. They are next trimmed by shears into irregular polygonal shapes, all cracks, flaws, and striations being rigorously cut away, and the faces of the sheets peeled until a smooth even surface is obtained. Bent or buckled mica should not be split at all, but rejected. The trimmed sheets are taken to the grading sheds, where this most important operation is carried out. The groups depending on transparency recognized lately by the Ministry of Munitions are: Clear, part stained, 2nd quality clear, 2nd quality part stained, fair stained, ordinary (rust and clay stained), densely stained, black spotted, and soft white. Generally, however, only four groups are recognized, namely: Clear, slightly stained, stained, and densely stained. In each group there are ten sizes, depending upon the largest rectangle which a sheet can give. The largest size is 72 in. square or over. It is estimated that 1½ lb. of trimmed mica is a good average yield from each hundredweight of mica won. The waste is therefore enormous. Much of this waste is of marketable quality, and could be converted into splittings for the manufacture of mica board, mica cloth, or mica paper, while other portions could be pulverized to form ground mica.

Mr. Maufe gives the following general conclusions: (1) The quantity and quality of the mica over a large area in Lomagundi are sufficient for the establishment of a regular mica-mining industry. (2) The mica is more regular in its distribution in the dykes than is usual in pegmatites. The deposits are seldom pockets, but are generally sufficiently continuous to be called "reefs," as this term is understood in South Africa. (3) The mode of occurrence of the mica, and the ease with which a marketable product can be obtained without much capital, makes the work suitable for the "small man," and in view of the large number of reefs scattered over a wide area it may be confidently anticipated that continual efforts will be made to work the mineral.

REINFORCED CONCRETE IN TIN-DRESSING PLANT.

At the meeting of the Cornish Institute of Engineers held on December 18, Ernest Gordon read a paper describing the use of reinforced concrete in the construction of the 100-ton mill and dressing plant at the Porkellis (Basset & Grylls) tin mine near Wendron. It was decided to use reinforced concrete on account of the high price of timber.

A cheap and effective form of reinforcement was obtained by using the strands of old scrap winding rope. This rope, 1½ in. diameter, was unstranded by hand in 100 ft. lengths, there being 6 resulting strands of roughly ⅜ in. diameter. No attempt was made to straighten out the twist in the strands; but, in order to free them from grease, they were coiled up and heated in the firebox of a boiler. The strands were very stiff and strong. A rough idea of their strength may be gathered by assuming that the original breaking stress of the rope, when new, was 60 tons, and, assuming that the present strands were half worn through, the breaking stress would be about 5 tons. The sand used was ideal for the purpose, being the washed refuse of the old alluvial tin streamers. It was composed chiefly of sharp quartz grains from ⅛ in. down in size, and contained no slime or earthy matter. The cement used was the ordinary Portland cement, which has been taken in the following costs at £5 per ton on the mine.

A wheelbarrow was taken as the standard unit for measuring the ingredients. In estimating the cubic contents of the final mixture, no allowance should be made for the cement, as the latter is so fine that it fills up the voids without appreciably adding to the volume. One cubic foot of cement is taken at 90 lb.

Great attention was paid to mixing, and all batches were turned over three times dry and then three times wet. It was found that by using little water the moulds could be freed more quickly, but this practice was given up as the cement lost so much of its strength, due to the difficulty of efficient packing in the wood moulds. Cement is quick setting by using hot water, the chemical action being hastened. This is useful in an emergency, but the resulting concrete is not ultimately so strong as that produced by the natural slow process. The best result is obtained by keeping the mixture moist for several days. Frost has a bad effect if the mixture freezes before it has had time to set, the result being that a spongy mass is formed owing to the included water expanding on becoming ice. To avoid this, straw was on one occasion placed around an important loading with successful results. Another method is to add common salt to the water before mixing in order to lower the freezing point. This, however, is not good practice. Thorough packing is most essential; for, if this is scamped, numerous voids are formed, with a corresponding loss of strength.

In compression concrete is very strong, but in tensile strength it is only, as a rough guide, equal to a twen-

tieth the strength of timber; consequently the added reinforcement should be equal to dealing with the load alone.

At the main shaft a 100-ton ore-bin was made of concrete. This ore-bin had to be connected with the mill 900 ft. away by a double tramway with an endless rope system of haulage. A cutting was made through some fields, and a gantry, 228 ft. long and 23 ft. high at the highest point, was erected. All the fence posts, sleepers, and gantry legs were made of reinforced concrete. The fence posts were of the ordinary type now becoming so common. They were 6 ft. long, 3 in. square at the top, and 5 in. square at the bottom end; 5 holes were cast in each for the fencing wire to pass through. Several moulds were made of wood, casting 6 posts at a time.

The mixture used consisted of one part cement to four parts sand. Reinforcement was made by two strands of wire rope, embedded in the mixture, one on either side of the holes. The holes were formed by five ½ in. iron rods which passed through all six posts. As soon as the mixture started to set, these rods were drawn out, leaving behind them nice clean holes. The cost per post for labour and material worked out at 1s. 1d. The weight is about 100 lb. each. They were sunk into

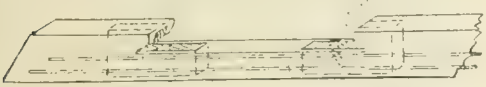


FIG 1. CONCRETE SLEEPER.

the ground 18 in., and set 8 ft. apart. The fencing wires used were old winding rope strands, the ends of which were fastened together by an ordinary fishplate bolt with two specially turned-up washers to clamp the strand on either side of it.

The sleepers were 8 ft. long, 5 in. wide, and 4½ to 3½ in. thick between the gauge; designed for two 1 ft. 6 in. tracks of 4 ft 6 in. centre. The wood moulds were made tapered so as to draw out. They differed in this respect from the moulds for the posts, which had to be taken apart after each cast. A mould would cast 5 sleepers at a time. The mixture was four to one, and the reinforcement was again made by two strands of old wire rope embedded close to the bottom of the sleeper. It will be seen from the sketch that the rail is held in position by means of an ordinary iron dog on the inner edge, the outer being wedged up against the concrete sleeper. To strengthen this portion, as well as to allow for a dog to be driven, special blocks of wood were cast as shown. Before placing these blocks in the moulds they should be thoroughly soaked in water. Otherwise they will swell and crack the concrete before it has had time to set. They should also be treated with some form of wood preservative to prevent dry rot. In moulding, a small piece of the rail to be used was set on the top of the mould in position. This held up the wood block while the material was being rammed. When the ramming is completed the rail can very soon be withdrawn, and the impression left in the concrete. The cost per sleeper for labour and material worked out at 1s. 8d. The weight was about 150 lb. A timber sleeper of this size would have cost 2s. 9d. on the mine. The concrete sleepers were found to be easy to lay, as the gauge was already fixed. Moreover, as they grasped the rails firmly, they could be placed at intervals of 5 ft. So far the only disadvantage is the weight. As the cars in use are only 10 cu. ft. capacity the comparative lack of resilience is not of importance.

In the construction of the gantry, timber was used for the road bearers and the legs were made of reinforced concrete. These legs vary in height from 9 ft. to 19 ft. 7 in. Those over 9 ft. were strengthened by a horizontal tie as shown in the sketch. The legs are of 12 in. by 9 in. section with a batter of 2 in. to the foot, and the caps 9 ft. long of 15 in. by 9 in. section. Four bolt holes were cast in the cap for bolting down the road bearers, and a bolt was cast in each end to support the hand rail. The foundations were so made that their tops came to certain fixed levels, to reduce the

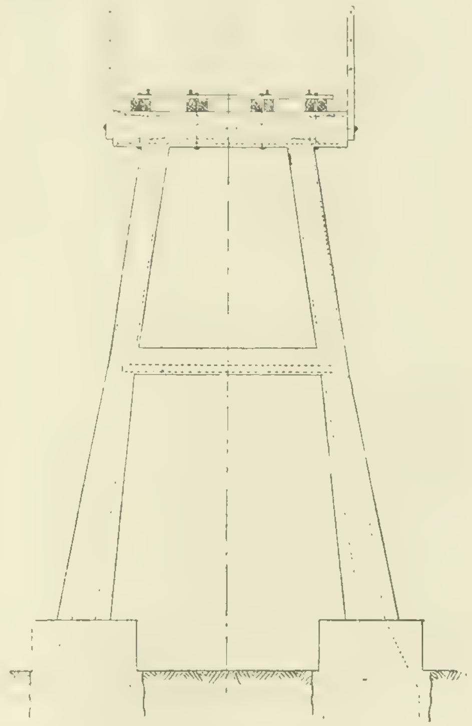


FIG. 2. CONCRETE GANTRY LEG: REINFORCEMENT SHOWN IN DOTTED LINES.

legs to standard lengths. The bottom half of the legs, up to and including the horizontal tie, was made first; and, after this had set, the top half of the mould was fixed and the work completed. The mixture used was four to one, and the reinforcement consisted of four strands in each limb. These strands, set in each corner, pass right down from the cap to the bottom of the foundation. The cross tie had 3 in. iron pipe filled with concrete placed an inch or so above the bottom, and this reached to the centre of each limb. The cap was strengthened by means of two 1½ in. iron pipes (also filled with concrete) embedded near the bottom, one on either side of the bolt holes. Under the top there were four horizontal strands, besides two which crossed the cap diagonally downwards. The cost of a 9 ft. leg including labour and materials came to 32s. 6d. against 66s. 5d. for one made of timber. The legs were set at 12 ft. centres apart, and all the woodwork on top was boiled in tar to preserve it.

To keep the haulage rope off the ground, rollers were made from lengths of 3 in. iron pipes. The spindle was held in position by a thin disc of concrete at either end of the pipe, the intervening space being filled with straw and paper. The weight of one of these rollers was just

over one pound, which compared favourably with one made with solid wood core, and the cost was about one half.

For the foundations for Holman's pneumatic stamps, after excavating to good solid ground, a 3 ft. base with plenty of area was formed of 14 to 1 concrete. From this base the main loading was formed. For the first 2 ft. a mixture of 8 to 1 was used, for the next 2 ft. 6 to 1, and finally a mixture of 4 to 1 brought the loading up to the anvil blocks. Owing to considerable trouble having previously been experienced through having wood blocks under the coffers, these blocks were dispensed with. Heavy cast-iron anvils were substituted to distribute the blow from the stamp over a sufficiently large area. A layer of hot pitch was used on the under side of the anvil; and, on the top of this, a ⅜ in. rubber mat

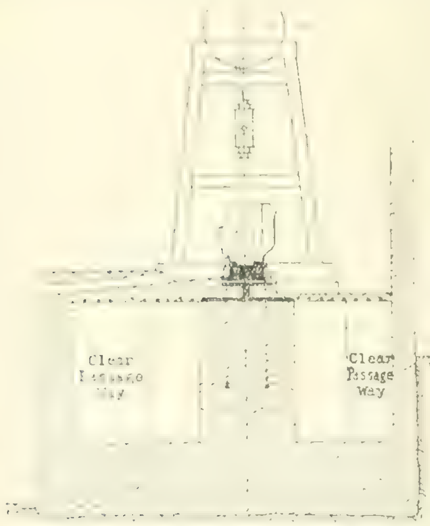


Fig. 3. Foundations for Holman Stamps.

was inserted. This arrangement has increased the stamp's output by 8% over the wood blocks, other conditions being equal. Foundation bolts were brought right up through the anvil and coffer, long washers taking the head of the bolts well above the discharge. Consequently, should these nuts become loose, they can be readily tightened without stopping the stamp. The reinforced concrete floor in front and behind, as well as the concrete-formed tray round the coffer, render the loadings quite dry beneath, so that inspection can be done with ease and comfort.

The concrete loadings for main belt drives were standardized, the ends of the original box being used time after time. The same applied to the crow-hole boxes which were all made tapered to permit their withdrawal. The horizontal launders which passed through the ends of the box were removed as soon as the mass started to set. All these launders were well soaked in water before using; otherwise they would swell and be difficult to extract.

For light walls for the wood buildings to rest on to bring them well clear of the ground, a mixture of 8 of stone, 6 of sand, to 1 of cement was used. This mixture, even with large stones added, gave a surprisingly strong result.

Several experiments were made in the making of concrete floors. It was found that good results were obtained by laying the ground over with stones from 3 in. to 4 in. cube and beating them well in. A layer of concrete was then added consisting of 6 of rough sand, 1 of fine sand, to 1 of cement. This mixture ran down between the stones, cemented them together, and formed a layer on top about 1 in. thick. When this had been roughly smoothed over, dry cement was sprinkled and a good hard face produced. It was found that a bag of cement (11 bags to the ton) would cover 80 sq. ft. of floor area.

The ore-bin behind the stamps was of the usual wooden V type with sloping bottom. It was found to be less expensive to cover the bottom with a layer of ferro-concrete rather than buy scrap sheet iron or boiler plates. A few iron sheets have been bolted on the top of the concrete where the actual blow comes from the dumped

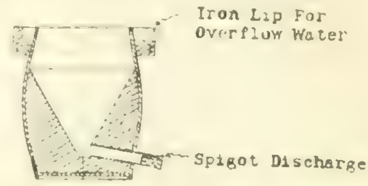


Fig. 4. Conical Dewaterer.

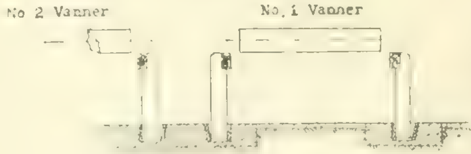


Fig. 5. Section of Vanner Loadings.

ore. So far the lining has shown no signs of wear, and the whole bottom of the bin has been made quite impervious to slime.

For the concrete stack for the Brunton calciner, an old iron stack 18 in. diameter, 18 ft. long, was used as the core. To avoid the concrete cracking, through the expansion of the iron from heat, straw was bound around it so as to form an air space. After the iron stack had been erected with its straw lagging, an outer mould 22 in. diameter and 3 in. long was centred and filled with 4 to 1 concrete. When this had set the outer mould was loosened, raised 2 ft. 6 in., and again filled. In this way the stack was built up in sections to the top. When in the course of time the iron core perishes through corrosion by gases, the concrete should take its place without interruption. Before this work was decided upon, a test was made to see how a similar mixture of concrete would stand the action of the hot gases; also to test the expansion of an iron core lagged with straw.

A section is shown of an oil barrel converted into a dewaterer. The concrete ring for the overflow water was cast in position, a few nails being driven into the barrel to prevent the concrete from slipping. For this ring a mixture of 4 to 1 was used, as well as a few single wires as reinforcement. Practically the only expense attached was in making the wood mould for the ring; but, once this has been made, it can be used time after time.

On dismantling Frue vanners, it is usually found that the sills have become rotten through the lack of ventilation from being embedded in concrete. The section shows the arrangement of vanner loadings recently put in, from which it will be seen that a considerable amount

of concrete has been saved as well as the sills. The wood box which surrounds the tenon and tightening wedge is made of rough timber. The concrete contracts around the box and tends to make the leg very secure.

The main shaft ore-bin, designed for a capacity of 100 tons, was rectangular in construction with a flat bottom. The front side rested on 4 pillars which also supported the floor of the bin to enable the cars to come underneath for filling. The landing stage and roof of the previous wood ore-bin, as well as the crusher loading, have been combined in the general design.

A ferro-concrete tank of 3,000 gallons capacity was made for gas engine cooling water. This tank was 6 ft. deep with sides 6 in. thick at the top and 9 in. at the bottom. Four pillars supported it 10 ft. off the ground. A mixture of 4 to 1 was used throughout the entire tank. Owing to considerable vibration being present, great care had to be taken with the reinforcement. A mesh of winding rope strands was made, set 6 in. apart, for the bottom of the tank. The strands were bent to continue up in the sides where they were woven with horizontal strands placed a foot apart. The strands were all placed as near the outside edge of the tank as possible. It was found on trial that the tank leaked slightly. By washing the inside with a mixture of lime and cement no trouble has been experienced since. The tank was braced on top by four ferro-concrete bearers which supported the water cooler. The cooler consisted of 12 poilite sheets placed horizontally one above the other, the water being made to cover the area of each.

Two travelling beams were constructed, of 23 ft. and 16 ft. 4 in. centres, for use over the gas engines. They were more or less experimental. They were reinforced with steel rails and lengths of complete wire rope. The latter was distributed throughout the beam in such a way as to break up the neutral axis. The mixture used was three to one; special care was taken in selecting the sand. So far they have answered their purpose well and were most useful when erecting the engines.

A number of concrete blocks were cast, 1 ft. 6 in. by 9 in. by 9 in. thick, hollowed out to leave 3 in. sides. These blocks were found very useful for quoins; moreover, being hollow, they were light for getting into position. When in position they can be filled with a cheap mortar which also serves to key them together. They were made in wood moulds which were fastened together by cottar bolts. The wood cores were made with plenty of taper, and well soaked in water before using. The mixture was 4 to 1. Very little water was used, so as to allow the cores to be withdrawn soon after packing.

Connecting Surface and Underground Surveys.— The method of connecting surface and underground surveys in connection with two shafts at the Throckley colliery, Northumberland, formed the subject of a paper read at the meeting of the Associates' and Students' Section of the North of England Institute of Mining and Mechanical Engineers, held at Newcastle-upon-Tyne on November 27, by Joseph Eltringham. The following account is taken from the report of the paper published in the *Iron & Coal Trades Review* for December 3. These two shafts are known as the Derwentwater and the Margaret respectively, and are some distance apart. The depth of the main seam is 243 ft. The plans of the separate pits having been laid down to the magnetic base by the magnetic-needle method and a holing effected between the two pits, it was decided to connect the two systems and so check the respective plans. For plumbing the shafts, a hand-manipulated drum was used, with wire 0·058 in. diameter, a pulley and cross-beam for lowering two weights (small and large), and a bucket containing engine oil. Operations commenced at the Derwentwater pit. The cross-beam was erected at the top of the shaft, and the pulley wheel was fixed in position so that the running-off side was in the centre of the shaft. The drum was then fixed on the pulley-wheel platform and the wire with a small weight attached passed over the pulley and gently lowered. When nearing the level where underground operations were to commence, the lowering ceased to allow for further elongation of the wire when the heavier weight was suspended. The wire was further lowered to the required position and the weight placed into the bucket containing oil. The weight was not allowed to immerse completely, so that any further elongation of the wire could be readily detected. To lessen the oscillations due to air currents the fan was stopped for a short period. A 6 in. transit theodolite was next set up near the shaft-bottom and a fore-sight established. There was a slight movement of the plumb-line, and its angular movements were measured several times. A mean position was determined, and from this the angle to the fore-sight observed. Before a base-line of sufficient length could be made five additional sights were necessary. This base-line, 590·25 links, was established by having bore-holes put in the roof, in which plugs were driven and staples fixed before final observations were taken. The distances were measured and booked in the usual manner. The party then returned to the surface by way of a second shaft near by, so as not to interfere with the plumb-line. The theodolite was set up at the surface a short distance from the shaft. The oscillations at the surface were very slight, and a fore-sight was fixed and the necessary observations and distances determined. The two shafts at the surface were connected by traversing in the ordinary manner, because the surface conditions, being level, favoured this method. Had the surface been of an undulating character a system of triangulation would have been the better method to adopt. A base-line, 1,140 links, was laid down as near the shaft as practicable, tiles were sunk into the ground to a depth of about 18 in., and a sufficient number of measurements taken so as to determine their position at some future date. It was from this base-line that the observations for determining the magnetic declination were taken. The traversing was continued, and when nearing the Margaret pit another base-line, 923 links, was laid down. The plumbing apparatus was now erected and wire suspended at the Margaret pit in exactly the same way as at the Derwentwater pit, traversing being carried on to the Margaret pit and the surface survey connected to the suspended wire. The party made their way underground by means of a day-drift travelling road to the seam at the shaft where operations were to be resumed. This was necessary so as not to interfere with the plumb-line in the shaft. The theodolite was set up underground, the wire observed, the angular movement measured, a mean position determined, and a fore-sight taken. A base-line, 405 links, was now established underground. The underground connection was made by connecting the two base-lines left near the two shafts. Several base-lines were established underground at convenient points so as to extend the survey into various districts.

The theodolite was only provided with a 2½ in. magnetic needle, and a miner's dial provided with a 6 in. magnetic needle was used to determine the magnetic bearings. The night following the surface survey the observations for the determination of magnetic declination by equal altitude of stars were carried out. The theodolite was set up at one end of the base and truly

centred, and a tripod set up at the other end, this also being truly centred and a lamp placed on the top. The lamp was used as a referring object. The zero of the graduated plate of the theodolite was made to coincide with this line, and the vernier plate released and allowed to rotate to any desired position. Three stars, each of the first magnitude, were selected. The first star was sighted and the horizontal and vertical angles noted. About 15 minutes later a second star was sighted, and in the same manner a third after another 15 minutes had elapsed. After crossing the meridian the last sighted star was the first to reach the altitude recorded on the west side of the meridian, and the horizontal angle was noted at the point of equal altitudes. The second star was then carefully followed until it corresponded with the altitude observed before the crossing, and again the horizontal angle noted. The same was obtained for the third star. Bisecting the horizontal angle passed through by each star the resultant line will be in the geographical meridian, and from this the azimuth of the base-line obtained. To find the magnetic bearing of this line the miner's dial was set up, clear of all magnetic attraction, about 50 yards from the theodolite, and a sight taken from the latter to the former, and vice versa. The dial was set up at other seven points around the theodolite. In this manner magnetic and azimuth bearings were obtained, and the mean of the difference between the two was the magnetic declination.

The clockwise angle between the various sights was measured and recorded as follows. After all the necessary adjustments of the instrument had been made the vernier A was brought near the zero of the graduated plate and clamped. The readings of both verniers A and B were noted. The telescope was then brought into perfect alignment with the back-sight and clamped. The vernier plate was then released and rotated clockwise until the fore-sight was in the field and accurately bisected by the hairs of the diaphragm. Both verniers were read. The above was repeated twice with vernier A near 60° and 120° of the graduated plate. The above method was continued throughout the survey, and after each sight had been taken a straight line was ranged out with lamps underground and poles at the surface and carefully measured, and a measurement checked in the opposite direction.

The magnetic bearing of the base at the surface having been determined, the remaining sights were calculated in relation to the magnetic meridian and the bearing and length of the tie-line obtained. The underground survey was calculated to an assumed meridian and the tie-line calculated. The difference between the assumed and the magnetic tie-lines was the bearing of the first sight underground. Knowing the magnetic bearing of the first sight, the remainder of the survey was calculated to the magnetic base. Twice in the underground survey observations were made to the miner's dial situate in an old roadway, and the two differed from the calculated by 6 minutes and 4 minutes respectively. This dial only read to three minutes. The plan was plotted by co-ordinates and compared with the working plan which has seen many years of service, and was found to be within the limits allowed.

Copper Losses in Slags.—In the *Engineering and Mining Journal* for December 4, F. E. Lathe, metallurgist to the British America Nickel Corporation, discusses the losses of copper in slags and the methods for determining the amounts of sulphide and oxide present in the slags. He also indicates lines of experiments for the reduction of losses. We quote this part of the paper herewith.

It is customary to place immediately below the blast furnace spout one large settler, the overflow from which goes to waste. Although the necessity for matte storage may require a settler of large size, it will often be found that two or more smaller ones in series will more effectively clean the slag; or the large settler may be followed by small ones. The fall of slag from one settler to another probably allows the escape of a certain amount of gas, which may have caused the flotation of matte particles. Such a treatment is especially desirable when analyses show that the percentage of sulphide copper in the slag is high, as may be true in matte concentration or in other cases with a high percentage of copper on the charge to the furnace.

If the oxidized copper in the slag be high, some may be reduced by the addition of coarse pyrite to the second-last settler of a series. This was done at the Grand Forks plant of the Granby company with some success. The coarse pyrite added settles to the matte, and the sulphur driven off by heat stirs up the slag and has an excellent chance to reduce oxides. The lower-grade matte produced in this way also has a tendency to cause the precipitation of dissolved sulphides, if present.

As regards reverberatories, owing to the presence of oxidized copper in the charge, and the comparatively neutral atmosphere in reverberatory smelting, the loss as oxide or silicate is likely to be high. To reduce this loss to a minimum there is no method more promising than that suggested some years ago by E. J. Carlyle. Mr. Carlyle thought that if a wall of refractory material were built across a reverberatory furnace near the skimming end, high enough to keep back the main body of matte, but low enough to allow the slag to flow over it, pyrite could be charged through the roof between this wall and the skimming door, thus bringing about a material reduction in the copper content of the slag. A separate tap-hole could be provided for the low-grade matte as well as a side door behind the dam for the removal of floaters. Such a practice would not involve radical changes in construction, and would appear to be of general application in reverberatory smelting.

If converter slag forms a large proportion of the charge, the sulphide content of the slag may increase. In such results, if the loss be due to sulphides floated by gas bubbles, the low-grade matte treatment may reduce magnetite introduced in the converter slag, and consequently bring down the sulphide loss, as well as reducing the oxides. To lower the sulphide content a succession of small settlers might also be effective, as suggested for blast-furnaces. In all such instances the amount of settling which can be done outside the furnace is dependent principally upon the degree to which the slag has been superheated before leaving the furnace.

Metallurgically speaking, it may be wasteful to pour converter slag into blast-furnace settlers, but one cannot say that such a practice is never justified. As in all other industries, smelting and converting are governed by commercial considerations, and these must be the deciding factors. This much may be said, however. In most plants possessing both converters and blast-furnaces, at least a part of the converter slag is re-smelted, and when this is done the slag to be poured into settlers should as far as possible be that produced in the early part of the blow, when oxidized copper is at a minimum. If the suggested modification of reverberatory furnaces should, upon trial, prove commercially successful, that would appear to be the logical outlet for whatever converter slag is not required for fluxing purposes.

Precipitation of Gold.—The October *Journal* of the Chemical, Metallurgical, & Mining Society of South Africa contains a paper by J. Hayward Johnson, entitled : "Notes on the Influence of Soluble Silica and Calcium Salts in the Process of Precipitation of Gold from Cyanide Solutions." As regards soluble silica the author quotes two cases : (1) A deposit found on the zinc in the sand solution precipitation boxes ; (2) a scum found at the head and between compartments of sand solution precipitation boxes. The sample (1) of deposit and metallic zinc received was stirred with water and the deposit decanted away from the metal until as much zinc as possible was eliminated. The purified deposit was dried and analysed with following results :

	%
Calcium Oxide	26·4
Carbon Dioxide	18·0
Zinc Oxide	9·0
Sand, etc., insoluble	0·8
Combined Water	18·0
Soluble Silica	22·8
Sulphur as Sulphate	0·7
Sulphur as Sulphide	1·0
Magnesium Oxide	0·9
Iron Oxide	1·1
Gold and Silver	0·22
Organic Matter, Lead, etc.	Traces.

The deposit was therefore practically composed of calcium carbonate and gelatinous silica containing water. The mixture was very readily soluble in dilute acids, but if the solution was heated, neutralized, etc., the colloidal silica at once assumed the gelatinous form and was deposited. The silica formed an impermeable coating on the zinc and prevented precipitation. If the solutions entering the boxes were perfectly clear, it is apparent that the silica must exist in the colloidal sol form and be deposited on the zinc in the gel form by chemical or galvanic disturbance.

(2) The scum from the precipitation boxes was practically the same as that found on the zinc shavings, consisting of calcium carbonate and colloidal silica mixed with a little wax. The latter was probably derived from candle grease and is the cause of the flotation of the scum.

The turbidity of the slime solution after 24 to 48 hours' settlement (KCy 0·005% CaO 0·008%) was due to silica in a very fine state of division (presumably colloidal suspensoids) which was not removed by the sand clarifiers. This turbidity remained in the plant for a period of about seven days, but did not show itself in every charge treated during that period.

The make-up water used in the reduction plant was obtained from a dam which received part of its water from a valley into which the drainage from several old sumps, slime dams, and the compound was delivered. The ignited solids contained in this water were as follows :

	Parts per 100,000.
Silica and insoluble	2·3
Oxides of iron and alumina	2·3
Oxide of calcium	13·0
Oxide of nickel	2·7
Oxide of magnesium	3·6

Two samples of so-called white precipitate, one from the East Rand and one from West Rand, showed on examination that they carried 37·95% and 38·75% silica, respectively, which was found in a very fine state of division, almost gelatinous.

The foregoing instances fairly demonstrate that colloidal silica has quite a considerable effect on precipitation. In connection with all these cases, considerable trouble was experienced in the filter press, the silica forming on the filter papers in a gelatinous film, almost impervious to water, and causing a rapid rise in pressure on the press.

Excessively burnt lime, when the limestone carries an amount of silica, is also responsible for the introduction of soluble silica into the solution.

The excess alkalinity in the solution circuit is well known to have a detrimental effect on precipitation, and this excess is sometimes caused by the slow solubility of the lime.

The deleterious influence of the sulphates and of carbonate of lime is no doubt due to the formation of protective coatings on the zinc. Regarding the sulphates, the trouble does not develop apparently until the point of saturation is reached (256 parts per 100,000), when it becomes rapidly acute. The use of the condenser circuit of the steam plant as make-up water, though the circuit water is valuable on account of its available heat during the winter months, is, owing to its prior concentration, very liable to develop this point of saturation, in conjunction with the neutralized acid salts of the ore. With the large amount of reclamation work being carried out on many mines and consequent treatment of partly oxidized ores, the amount of calcium sulphate in solution tends to increase, and during the long winter drought usually develops trouble.

A Cyanide Clean-up Problem.—In the *Monthly Journal* of the Chamber of Mines of West Australia for September, W. B. Chomley gives an account of difficulties encountered in the cyanide clean-up at the Oroya Black Range gold mine and the method of surmounting them. The difficulties arose from the presence of copper in the ores.

It had been the custom to do the smelting in a tilting furnace, and to refine the resulting bullion by the well-known method of stirring sulphur into it while molten. The practice of smelting with an oxidizing flux in a clay-lined crucible had been tried and had proved successful as far as the grade of bullion was concerned ; but it had been abandoned as being too tedious, owing to the low gold contents of the slime. The clarifying arrangements were not equal to the capacity of the rest of the cyanide plant ; consequently the solution coming to the extractor boxes was frequently cloudy. This accounted for the large bulk of poor slime which had to be handled at each clean-up. Much might be said as to the comparative merits and disadvantages of these two methods of gold-refining, but it is only necessary here to remark that by the use of the sulphur method, even after all the gold in the matte and ashes has been taken into account, a slight deficiency has been observed. This loss is difficult to explain, but is easy to estimate ; while on the other hand, that which occurs while charging an open pot in a wind furnace is quite simple to understand, but almost impossible to estimate.

Clay-lined pots had been tried in the tilt furnace, but they were not a success, for as soon as a crack or flaw developed in the lining, which in these pots is not removable, the carbonaceous material composing the outer shell was subjected to the oxidizing action of the whole of the charge, usually with disastrous results, as these cracks generally occurred at or below the level of the molten metal.

In the early life of the mine, the copper had been an unimportant factor, but as the upper levels became depleted and the proportion of ore drawn from the sulphide zone increased, the copper contents of the cyanide bullion did likewise, until a stage was reached when it amounted to over 50% of the total. This increase in the copper in the ore had no deleterious effect upon the recoveries, as the undissolved gold in the residue seldom exceeded two shillings in either the leaching or agitation plants. Precipitation in the zinc-boxes sometimes gave trouble, but although it was demonstrated that copper-coated zinc was a less active precipitant than

the clean shavings the fact that while the presence of copper was constant, these periods of bad precipitation were intermittent, indicated that the seat of the trouble lay elsewhere.

Of the many possible causes that were considered in the search for an explanation for these periods of partial breakdown in the precipitation, that connected with varying ratio of zinc cyanide to free KCN seemed to be the most probable. The physical condition of the solution, that is, whether it was clear or cloudy, seemed to have no direct connection with it. It was always noticed that the new zinc in the lower compartments of the extractor boxes quickly became coated with a film of copper and that as it was moved up toward the head of the box to take the place of that which had been consumed, the copper was gradually replaced by gold, and that short zinc in the top compartment was practically copper free. Obviously a simple way of obtaining bullion free from this base would have been to take out only the short zinc and to leave the remainder for the next clean-up, but unfortunately economic reasons demanded quite the opposite course.

The chief trouble, and the one with which this paper is mainly concerned, arose through the corrosive action of the roasted slime, or rather the oxidized copper, upon the plumbago crucibles. The flux which had been found most suitable was approximately as follows: roasted slime 100 parts, borax glass 40, silica 5. It will be noticed that the percentage of silica here is very low; but it must be remembered that the slime itself contained some gangue material which had escaped the clarifier. Sometimes it was necessary to leave out the silica and add sodium bicarbonate in order to obtain a fluid slag. An over-silicious slag was really worse on the pot than a basic one, as the time and temperature required for fusion were increased. It was seldom at that time that a pot lasted out one full clean-up, and it often happened that one ran through during the first charge, and the amount of work and trouble that this entailed was considerable.

At that time the supply of crucibles, like all other mining stores, was very uncertain, but it was imperative that some means should be found to stop this destruction of valuable and perhaps non-replaceable articles. Several attempts were made to remove the copper from the slime prior to smelting. On an experimental scale this was quite simple, but many difficulties arose when it came to put any of these methods into practice. It was found that boiling the raw slime in concentrated sulphuric acid would accomplish the desired purpose, but this was quite impracticable with the plant available. Dilute nitric acid was tried, but although it attacked the copper, owing to the presence of much chlorides in the water supply, an appreciable amount of gold went into solution, which discouraged further investigation in that direction. The copper oxide was very soluble in dilute sulphuric acid, and a clean-up carried out on these lines produced bullion almost free from base, and also reduced the work of smelting to a minimum; but it was found to be absolutely necessary to clear the slime before bringing it into contact with the liquid, otherwise great loss by dusting would take place, and in dealing with a large quantity of material, this required more time than circumstances allowed. Another serious objection to this second acid treatment was the extra handling involved.

As a return to the original method of smelting with the certainty of having to refine the bullion seemed inevitable, the matter was viewed in a different light. As the whole of the trouble had been caused by the copper, which, after being oxidized by the roast, would be reduced back to metallic state at the expense of the pot, the question which presented itself was "Why roast at all?" It was realized that some of the zinc, which otherwise would have been roasted off, would find its way into the bullion, but it seemed safe to assume that in the presence of so much copper this would be a negligible quantity. Accordingly a sample was dried at a low temperature, fluxed on its calculated roasted weight, and fused in a small plumbago crucible. The result was encouraging, but the dried slime proved very dusty and more difficult to handle than that which had been roasted thoroughly, so trials were made on damp slime, with equally satisfactory results. Some misgivings were felt before attempting to smelt wet gold-slime on a working scale, and the first charge was very carefully fed into a barely warm pot after a layer of borax had been first sprinkled over the bottom. These precautions were subsequently found to be unnecessary, and wet slime would be fed into a red hot pot without any ill effect. It is not known exactly what percentage of moisture the slime held, but it had only been dried on a vacuum filter and was distinctly wet before it was fluxed. No great evolution of gas or steam took place during fusion, but the charge just sank quietly down and was periodically topped up. A good deal of the surplus moisture was taken up by the borax glass in the flux, which caused the whole to set into a fairly dry-looking mass. A section of the charge after it had been going for some time would have disclosed a gradual transition from the wet slime on top, through a layer of what looked like ordinary roasted slime, then a zone of slag with the molten metal beneath. The resulting bullion was not appreciably worse than formerly, and there was no noticeable action on the pot at all. The actual time taken in smelting was somewhat longer; but this was counterbalanced by that saved by cutting out the roasting. The manual labour was reduced, which was a consideration during the hot months.

After the first pot had been in use for three months it was removed as a precautionary measure. Upon examination it was found to be quite sound and looked good enough to have lasted as long again. This effectually put an end to those mishaps which had unfortunately become the rule rather than the exception, and the output was not again delayed while the contents of the ashpit and furnace were being re-smelted. It was really the smelting of this mixture that first suggested the course ultimately adopted, as it was noticed that in these cases the pot was not attacked to the same extent as usual. The cause of this was soon traced to the reducing action of the small pieces of coke in the charge which protected the less easily oxidized graphite in the crucible.

It may be mentioned that the author has subsequently made trials of this method on other mines where the same circumstances did not prevail, and as might be expected, in the absence of any other base in large quantities, the remaining zinc was sufficient to spoil what would otherwise have been fair grade bullion, and the process was not applicable, but under the conditions described it can be claimed that it was a decided success.

SHORT NOTICES

Stope-Filling.—The November *Bulletin* of the Canadian Institute of Mining and Metallurgy contains a paper by Walter Herd on the proposed application of hydraulic stowing to the submarine coal workings at Sydney, Nova Scotia.

Stope-Filling.—At the November meeting of the Junior Institution of Engineers, R. H. Squire read a paper on hydraulic sand-packing as practised in Indian collieries.

Electric Power in Mines.—*Engineering* for December 17 contains a paper describing the electric winding, hauling, and ventilating plant at the Easington Colliery, Durham. The electric plant was supplied by the General Electric Co., Ltd.

Compressed Air.—At the December meeting of the North of England Institute of Mining and Mechanical Engineers, J. T. Pringle read a paper on the production and transmission of compressed air in mines.

Francois Cementation Process.—At the meeting of the South Wales Institute of Engineers held at Cardiff on December 16, H. Standish Ball read a paper on the Francois system of cementation for stopping the flow of water in shafts and drifts.

Surveying.—The *Colliery Guardian* for December 17 prints a paper read at the South Wales branch of the Institute of Mine Surveyors of Great Britain on the line of collimation in dumpy levels, etc.

Electrolytic Zinc.—*Mining and Metallurgy* for December contains an abstract of a paper on the electrolytic zinc plant at Anaconda, by F. Laist, F. F. Frick, J. O. Elton, and R. B. Caples, to be read at the February meeting of the American Institute of Mining and Metallurgical Engineers.

Electrolytic Zinc.—The *Mining and Scientific Press* for December 4 contains a paper by H. R. Hanley on the electrolytic method of producing zinc. The author's experience was at Bully Hill, California.

Electrolytic Zinc.—In the *Engineering and Mining Journal* for December 11, G. C. Heikes describes the electrolytic zinc plant of the Judge Mining & Smelting Co., Park City, Utah.

Melbourne University.—In the *Industrial Australian and Mining Standard* for October 14, A. J. Higgin describes the metallurgical department of Melbourne University.

Metallurgical Laboratory.—In the *Engineering and Mining Journal* for November 20, H. O. Hammond describes the laboratory attached to the smelting plant of the United Verde Extension copper mine, Arizona.

Gold-Mining in the Philippines.—In the *Mining and Scientific Press* for December 4, C. M. Eye and M. F. Dodd commence an article on metallurgical practice at the Benguet Consolidated gold mine in the Philippine Islands.

Atmospheric Impurities.—In *Chemical and Metallurgical Engineering* for December 8, Osborn Monnett commences an article on the determination of atmospheric impurities, with particular reference to the atmosphere around smelting works, as at Salt Lake City.

Phosphorus from Rock Phosphate.—In *Chemical and Metallurgical Engineering* for December 1, W. H. Waggaman and T. B. Turley describe the production of phosphoric acid from rock phosphate by smelting with sand and coke in a furnace fired with oil fuel and electrostatically precipitating the phosphoric acid evolved.

Mandy Mine.—The November *Bulletin* of the Canadian Institute of Mining and Metallurgy contains a paper by G. R. Bancroft on the mining operations at Mandy mine in The Pas district, Manitoba.

Manitoba Geology.—The November *Bulletin* of the Canadian Institute of Mining and Metallurgy contains a paper by R. J. Colony on the occurrence of norite, similar to that at Sudbury, at a point twenty miles east of the southern end of Lake Winnipeg.

Bolivian Tin Mines.—In the *Engineering and Mining Journal* for November 20, J. T. Singewald describes the tin deposits in the Quimsa Cruz mountains, Bolivia.

Spitsbergen.—At the December meeting of the Mining Institute of Scotland, H. M. Cadell read a paper on coal mining in Spitsbergen.

Kent Coal.—In the *Iron and Coal Trades Review* for December 10, H. A. Baker writes on the structural features of the Kent coalfield.

Oil in Palestine.—At the meeting of the Institution of Petroleum Technologists held on December 14, Paul H. Mangin read a paper on boring in Palestine.

South African Diamonds.—At a meeting of the Royal Society of Arts held on January 3, F. C. Cornell read a paper on the alluvial diamondiferous deposits of South-West Africa.

British Columbian Topography. — In the *Geographical Journal* for January, Howard Palmer describes the topography of the region north of Revelstoke, British Columbia, including the Gold Range and the northern Selkirk mountains, a hitherto unmapped territory.

RECENT PATENTS PUBLISHED.

☞ *A copy of the specification of any of the patents mentioned in this column can be obtained by sending 1s. to the Patent Office, Southampton Buildings, Chancery Lane, London, W.C.2., with a note of the number and year of the patent.*

12,969 of 1918 (154,240). U. A. GARRED, New York. Introduction of powdered fuel into the blast of blast-furnaces to take the place of coke in the reactions.

4,938 of 1919 (154,240). M. A. ADAM, J. STEVENSON, and A. T. MABBITT, London. Removing tin from scrap by dissolving in strong solution of ferric chloride rich in tin, and electrolysing the solution obtained.

12,415 of 1919 (153,926). W. M. GOODWIN and A. F. G. CADENHEAD, Kingston, Ontario. Electric smelting process for recovering vanadium from vanadiferous iron ores.

16,833 of 1919 (150,490). J. P. MELLOR, Swansea. Method of producing metallic powders by making jets of steam or compressed air impinge on sheets of molten metal.

17,084 of 1919 (153,352). R. S. SHERWIN, St. Louis. Improved process for precipitating aluminium hydrate from alkali aluminate solutions.

17,975 of 1919 (154,265). G. MORIMOTO, Kyoto, Japan. Claim (1): "A rock-drill or rock-boring machine of the percussive type, comprising a hammer or striker adapted to make a forward stroke divided into two stages through the medium of a blow-inducing cam; and a U-shaped rod having one of its limbs formed to afford curved surfaces upon which a grooved pulley is adapted to rest and to shift either to a straight high face from a straight low face by passing through a curved face of the rod, or to a straight high face from a point of the curved face according to the extent of movement of the striker relatively to the pulley."

18,337 of 1919 (130,334). F. M. WIBERG, Falun, Sweden. Furnace for smelting iron ores with gaseous fuel.

15,210 of 1919 (153,931). A. R. MANGNALL, Chester, and R. F. IRVING, Bristol. Earth-boring machines for boring holes through soft earth.

19,391 of 1919 (153,649). I. B. HOBSBAWN, Brighton, and J. L. GRIGIONI, Valparaiso. Method for recovering nitrate from solutions, particularly with the object of separating common salt and sulphate from the liquors.

19,579 of 1919 (153,659). W. H. DORMAN & CO., LTD., and J. HANSON, Stafford. Hydraulic wave generators for use in connection with the wave-transmission rock-drill and similar tools.

20,662 of 1919 (153,700). BRITISH THOMSON-

HOUSTON CO., LTD., London. Controlling mechanism for electric hoists and winding engines.

21,608 of 1919 (132,260). T. H. PALMER, H. [illegible], and [illegible], Broken Hill. The addition of sulphur in elemental form to the liquids used in treating weathered ore in the flotation process.

21,074 of 1919 (153,983). A. FRANCE, Liége. Coal washing apparatus consisting of a number of troughs arranged in cascade formation.

22,376 of 1919 (154,373). S. O. COWPER COLES, London. Means for producing a tempered or springy copper by electrolysis of sulphate, by rotating the cathode at a high speed and adding arsenic to the solution.

22,388 of 1919 (152,840). UNION ALBIDE CO., New York. Method of producing and using magnesium-silicon alloys in connection with the deoxidizing process in purifying iron or steel.

24,383 of 1919 (152,509). C. F. PRIEST, Redcar. Regenerative gas-fired kilns for burning ore briquettes or high-temperature refractory materials.

24,744 of 1919 (134,825). ELECTROLYTIC ZINC CO. OF AUSTRALASIA, LTD., Melbourne. Method of giving a sulphatizing roast to zinc sulphide ore preparatory to leaching.

25,300 of 1919 (133,960). E. FOURNEAU, La Bouverie, Belgium. Apparatus surrounding the steels of rock-drills whereby the dust created may be drawn away.

26,317 of 1919 (152,526). M. UCHINO, Ashio, Japan. Refining arsenic soot by distilling through a mixture of copper and iron oxides.

26,511 of 1919 (151,842). A. STEVENSON and A. LOGAN, Glasgow. Improved cutting tools of coal-mining machines.

27,115 of 1919 (140,050). DEUTSCHE MASCHINENFABRIK, Duisburg. Bessemer plant having a pair of rails on which the casting ladles travel suspended from the converter staging.

27,859 of 1919 (152,533). E. PICKARD, Nottingham. Safety apparatus for supporting mine cages in case of the failure of the winding rope.

28,209 of 1919 (154,434). J. R. BROADLEY, London. Claim (1): "In a machine (tube-mill) for grinding ores, minerals, stones, and the like, means for evacuating finished material comprising a classification compartment with access from a grinding compartment through passages provided in a diaphragm separating the two compartments and with a discharge outlet for decanting fine material in suspension in water or other liquid."

28,749 of 1919 (151,854). LINDSAY LIGHT CO., Chicago. Method of extracting thorium compounds from monazite sand.

28,845 of 1919 (152,879). E. A. ASHCROFT, London. Improved electrolytic cell for decomposing fused magnesium chloride.

29,239 of 1919 (153,182). W. GRAHAM, South Shields. A detonator for blasting purpose, damp-proof and positive in its action.

30,977 of 1919 (152,887). H. C. PEDERSEN, Trondhjem, Norway. Arrangement of roasting furnaces so as to obtain the sulphur in elemental condition.

31,201 of 1919 (140,746). DYNAMIT A.G. VORMALS ALFRED NOBEL, Hamburg, and P. NAOUM, Cologne. A blasting gelatine that can be safely used in the presence of fire-damp.

31,560 of 1919 (153,481). W. MORLEY MARTIN, Redruth. Improvements in the motion and groovings of reciprocating tables.

32,409 of 1919 (152,549). F. QUINONERO, La Union, Murcia, Spain. A magnetic separator suitable for separating magnetic iron oxide from galena.

32,853 of 1919 (154,471). C. HEBERLEIN, London. Improvement in the inventor's process of depositing nickel electrolytically

1,711 of 1920 (153,500). S. E. SIEURIN, Haganas, Sweden. Extracting alumina by treating the raw material with hydrochloric acid, liquid and then gaseous, and calcining the chloride produced

2,668 of 1920 (151,884). F. BECKETT and R. C. ANDERSON, Glasgow. Electric haulage gear for mines.

3,311 of 1920 (123,503). C. A. EDGLEY, Yarm-on-Tees. Method of leaching chloridized-roasted ores.

4,376 of 1920 (152,916). J. B. GUIMET and A. GUILLOCHON, Fleurien-sur-Saône, France. In the manufacture of ultramarine, the use of alkali sulphites or bisulphites in place of carbonate and sulphate of soda usually employed.

4,695 of 1920 (139,173). L. H. DIEHL, Berlin. In the smelting of iron ores, an arrangement for blowing air through the slag for the purpose of recovering the sulphur contained therein as sulphur dioxide.

4,975 of 1920 (139,194). V. GERBER, Ober Uster, Switzerland. Smelting of alumina mixed with carbon in an electric furnace using alternating current.

5,549 of 1920 (154,108). S. O. COWPER-COLES, London. Method of electrolytically precipitating alloys of copper and zinc.

7,747 of 1920 (153,830). T. M. ALLISON, Newcastle-on-Tyne. A centrifugal separating machine for removing earthy matters from coal.

12,791 of 1920 (152,281). G. H. T. and P. RAYNER, Sheffield. Improved valve for rock-drills.

13,536 of 1920 (154,512). DORR CO., Denver. An improved classifier.

14,711 of 1920 (152,939). R. H. HARRIS, Seven Sisters, Glamorgan. Improvements in the inventor's electric detonators.

16,525 of 1920 (145,442). FRIED. KRUPP GRUSONWERK, Magdeburg-Buckau, Germany. Improved magnetic separator.

18,032 of 1920 (145,734). FRIED. KRUPP GRUSONWERK, Magdeburg-Buckau, Germany. Device for closing the tap-hole in smelting furnaces.

20,656 of 1920 (148,818). H. STEHMANN, Berlin. Blast-proof closing of discharging devices for blast-furnaces.

27,659 of 1920 (152,990). TH. GOLDSCHMIDT, Essen, Germany. Method of obtaining carbon-free ferro-chromium from chrome-iron ores by the alumino-thermic process.

NEW BOOKS, PAMPHLETS, Etc.

☛ Copies of the books, etc., mentioned below can be obtained through the Technical Bookshop of *The Mining Magazine*, 724, Salisbury House, London Wall, E.C.2.

The Oil-Shale Industry. By VICTOR C. ALDERSON. Cloth, octavo, 180 pages, illustrated. Price 26s. New York: Frederick A. Stokes Company.

Hitherto when it has been necessary to get together some general information concerning the technology of oil-shale, the amount of reference work needed in elucidating the really fundamental data has proved to be no small task, and if for no other reason than that, Dr. Alderson is to be congratulated on the production of the present comprehensive volume. As will be gathered from the bibliography included at the end of the book, most of our knowledge of the subject is scattered over a wide field of literature, some of it easy, but most of it difficult, of access to the average person outside a technical or scientific institution. One result of this is that the prevalent ideas concerning the oil-shale industry are somewhat confused and even conflicting, and we

therefore welcome the appearance of a volume which summarizes all the information thus far accumulated in so satisfactory a manner.

The book is essentially economic, and does not attempt to deal with the many vexed geological and chemical questions as yet remaining unsolved with regard to shale oil; probably this is a good feature, since in the present state of our knowledge little value would accrue to such considerations unless they were of a very exhaustive character. With the growth of the industry both at home and abroad research is bound to receive a further stimulus, and much that is at the moment imperfectly understood will doubtless be made clear in the light of new facts and hypotheses thus advanced. To this end, and as an offset against the gradually declining production of crude oil, the author's main plea throughout the work is the immediate development of the world's oil-shale resources, and in this he has the fullest support of all far-sighted men of to day.

We in this country are constantly hearing of the "vast mountains of oil-shale" hitherto untouched in America, and possibly we may regard such a statement as a piece of pardonable exaggeration on the part of our enthusiastic friends in the States. But Dr. Alderson shows in a most convincing manner that far from being an exaggeration it is possibly but a modest computation of the resources of that country. We read (page 29) that in the Utah portion of the Uintah basin alone there are 40,000,000,000 tons of shale which, yielding a barrel of oil to the ton under normal working conditions, will require over 500 years for their exhaustion; similarly in Colorado there would seem to be at least 800 years' supply! Such estimates as these, which omit all consideration of oil-shale deposits elsewhere, both in America and other countries, are sufficient in themselves to make us wonder why such valuable resources of oil fuel should remain comparatively undeveloped until now, and we are driven to seek an explanation in the study of the many commercial aspects of the problem. Of these, one factor stands out very clearly, quite apart from prevalent economic conditions, and that is the general crudeness of present methods of shale-refining. It is well known that no one method of retorting, for example, will suit all facies of shale; a process well adapted for the treatment of the Scottish shale may be quite inapplicable in the States or in other parts of the world, where the nature of the shales, climatic conditions, and economic criteria are all varying factors, and where the difficulties of initiating satisfactory commercial processes to meet local requirements are extremely acute. Such obstacles can only be overcome by much detailed experimental work, work which we are glad to see is at last claiming the attention of experts both in this country and abroad.

The author deals at some length with the several processes of refining at present employed, and he supplies some valuable information from the results of much experimental work carried out at the Colorado School of Mines, of which he is himself the president. In this country similar work has been done and is in progress in the Oil Technology Department of the Royal School of Mines, and we take this opportunity of framing a few criticisms of the method of shale distillation carried out at the former school, and described in detail in the present volume on page 94 et seq.

(1) The cast-iron retort or pot-still described by Dr. Alderson might with advantage be replaced by an iron tube, since uniform heating of the shale is thus much more rapidly obtained.

(2) When carrying out the distillation with steam, there is a danger in using the pot-still, since the steam will tend to take the easiest channel through the material without passing uniformly through the shale; this danger is minimized with a tube retort, especially if the latter be narrow, say 2½ in. internal diameter.

(3) There is also a danger of some of the oil condensing on the cooler upper surface of the pot-still, and in the vertical portion of the delivery tube, thus dropping back on to the hot shale and becoming decomposed, a possibility largely eliminated in the tube retort.

(4) More rapid methods of estimating the yield of ammonium sulphate can be employed than that described by the author. If the ammonia water is not too strongly coloured, a known excess of normal $NaOH$ solution may be added; the oily bases thus liberated may be extracted by shaking with petroleum ether, when by titrating back the aqueous layer with standard acid, the amount of ammonia present in the liquor may be easily determined. Where the ammoniacal liquor is too strongly coloured to make this method possible, the yield of sulphate may be determined by rendering it strongly alkaline with $NaOH$ and distilling off the ammonia into standard sulphuric acid. The oil must of course be separated from the liquor in the first place.

The book is markedly free from technical and literary inaccuracies, and is in itself a tribute to the patient and thorough work which the author has been and is doing; his inquiries made personally in this country during the early summer months of last year with reference to the oil-shale industry in England and Scotland, and reported at some length in the October issue of the Quarterly of the Colorado School of Mines, clearly show the broadmindedness and sincerity of the effort which he and his pupils are making in an organized endeavour to establish the foundations of a far greater oil-shale industry than the world has yet appreciated.

H. B. MILNER.

The Sunset-Midway Oilfield, California. By R. W. PACK. United States Geological Survey, Professional Paper 116.

This memoir deals with the geology and technology of the oil resources of an area situated at the southern end of the San Joaquin valley, Kern County, California, and is yet another example of the high standard of excellence attained by American publications of this nature. It constitutes Part I. of the Official Report on the Sunset-Midway field, and besides giving a thorough account of the occurrence of petroleum there, it contains some most valuable information on oil accumulation which, by reason of its wider application, repays careful study.

The author first treats of the stratigraphy of the district, which consists essentially of an enormous mass of Tertiary sediments reposing unconformably on a complex of granitoid rocks with associated metamorphics, forming part of the great batholith of the Sierra Nevada. These sediments have an estimated thickness of 18,000 ft., and though not expressive of continuous deposition, they range in age from Eocene to Pliocene, with but few important stratigraphical breaks in the succession. Of these deposits the central Miocene diatomaceous formation is both geologically and economically the most characteristic, and is referred to here as the Maricopa Shale series, the lower part of which is equivalent to the younger beds of the better known Monterey group of this region. The oil is regarded as indigenous to this series, which has a thickness here of nearly 5,000 ft., and most of the productive horizons of this field are located in and about these shales.

The geological structure of the area is by no means simple. The accumulation of oil has apparently been controlled by a series of folding movements along a line trending W.N.W.-E.S.E., a direction somewhat

oblique to the strike of the main coastal range. This folding has produced a series of anticlines and synclines, in places closely packed together, with a certain amount of concomitant faulting, especially in the south, in the San Emigdio Mountains, where the main structure lines are trending practically E.–W. Most of the productive fields of the region to the west of the San Joaquin valley, embracing the Sunset-Midway district, are situated near the axes of these anticlinals.

With regard to actual production, up to January 1, 1918, 2,827,900,000 barrels of oil had been obtained from over 2,000 wells drilled; from the statistical details given by Arnold in the "Manual for the Oil and Gas Industry," pp. 148–152, it is evident that the future prospects of the Sunset-Midway field are exceedingly good, such being the impression also conveyed from a study of this memoir and of the excellent maps included.

H. B. MILNER.

The Mineral Industry: Its Statistics, Technology, and Trade during 1919, Vol. xxviii. Edited by G. A. Roush and Allison Butts. Cloth, octavo, 902 pages. Price £2. 15s. 0d. New York and London: McGraw-Hill Book Company.

Ontario Department of Mines 29th Annual Report. Part IV: Kirkland Lake Gold Area, by A. G. Burrows and P. E. Hopkins.

Ontario Department of Mines 29th Annual Report. Part III: Ben Nevis Gold Area, by C. W. Knight; West Shiningtree Gold Area, by P. E. Hopkins; Matachewan Gold Area, by A. G. Burrows; Argonaut Gold Mine, by C. W. Knight; Gowganda Silver Area, by A. G. Burrows.

Coal in Great Britain: The Composition, Structure, and Resources of the Coalfields, Visible and Concealed, of Great Britain. By Dr. WALCOT GIBSON. Cloth, octavo, 320 pages, illustrated. Price 21s. net. London. Edward Arnold.

COMPANY REPORTS

Dolcoath Mine.—The report of this Cornish tin-mining company for the six months ended June 30 last shows that 30,052 tons of ore was treated, yielding 338½ tons of tin concentrate, or 25·2 lb. per ton. This was sold for £70,751, and in addition £1,918 was received from the sale of crude arsenic. Other items brought the total receipts to £74,732, against which there was an outgoing of £86,006, including £3,213 paid as debenture interest. The loss for the half-year was £11,275. Since the end of the half-year the bottom workings have been abandoned, and operations have been continued on a reduced scale. The proposal to explore to the north is given in detail elsewhere in this issue.

Sub-Nigel.—This company was formed in 1895 to acquire property on the dip of the Nigel gold mine in the Heidelberg district of the Far East Rand. In 1909 the adjoining property of the Nigel Deep was absorbed. More recently property on the dip in the Grootfontein has been acquired, and an extensive scheme of development inaugurated. The control is with the Consolidated Gold Fields of South Africa. The report for the year ended June 30 last shows that 117,304 tons of ore was sent to the mill, where 38,911 oz. gold was extracted by amalgamation and 33,862 oz. by cyaniding, being a total of 72,773 oz., or 12·33 dwt. per ton. The gold was sold for £384,365, of which £76,311 represented premium. The value of the yield per ton was 65s. 1d., or excluding premium 52s. 2d. The working cost was £253,636, or 42s. 11d. per ton, leaving a profit of £130,729, or 22s. 2d. per ton, out of which £70,000 was distributed as dividend, being at the rate of 10%. The developments have not maintained the ore reserve, which stands at 284,000 tons averaging 10 dwt. The new vertical shaft reached the reef at a depth of 2,379 ft. in November, 1919, and connection has been made with the 17th and 21st levels. Since the close of the company's financial year, developments on the 21st level have disclosed a number of runs of profitable ore.

Knights Deep.—This company was formed in 1895 to acquire deep-level claims in the middle-east Rand, and milling commenced in 1903. The control is with the Consolidated Gold Fields of South Africa. From 1905 to 1917 satisfactory dividends were paid regularly. In September, 1920, the mill was destroyed by fire. Under the conditions now ruling at this low-grade mine, it was impossible to rebuild the mill, so the company is to go into liquidation. The report for the year ended July 31 last shows that 1,070,200 tons of ore was raised and milled, for a yield of 193,881 oz. This gold was sold for £1,049,480, of which £224,236 represented premium. The income per ton milled was 19s. 7d., of which 4s. 2d. was premium. The working expenses were £940,965, or 17s. 7d. per ton, leaving a working profit of £108,514, or 2s. per ton. A dividend of 3¾% was paid in January, 1920, absorbing £27,882. The ore reserve was estimated on July 31 at 727,000 tons, averaging 4·8 dwt. over 65 in.

Luipaard's Vlei Estate & Gold.—This company was formed in 1888 by the Consolidated Gold Fields to work a gold-mining property in the far west Rand. Milling was started in 1898, but was suspended on the outbreak of the Boer war, and was not resumed until 1906. In 1909 the adjoining Windsor mine was absorbed. In 1912 the control was acquired by L. Ehrlich & Co. The property consists of four sections, two on the Main Reef Series, and two on the Battery Reef to the south. Small dividends were paid in 1908, 1909, and 1916. The report for the year ended June 30 last shows that 226,985 tons of ore averaging 4·99 dwt. per ton was sent to the mill, where 52,523 oz. of gold was extracted by amalgamation and cyaniding, being a yield of 4·628 dwt. per ton. The amount realized, including premium, was £276,026, while the working cost was £247,906, and the item for development redemption was £34,047. Thus the total working cost was £281,954, and the adverse balance for the year £5,928. A shortage of native labour and a fall in the stoping width of the reefs had a very serious effect on the output and revenue, and at the same time the costs went up 3s. 6d. as compared with the previous year. An advance in the gold premium came to the rescue, however, and obviated the contemplated stoppage of operations. It is now intended to resume development directly a supply of natives can be obtained. The reserve stands at 701,847 tons averaging 5·2 dwt., together with 84,564 tons partly developed expected to average 5·71 dwt. per ton.

Witbank Colliery.—This company was formed in 1896 to acquire coal lands in the Middelburg district of the Transvaal, about 90 miles east of Johannesburg. The control was with Neumann's, but is now with the Central Mining & Investment. The report for the year ended June 30 last shows that sales amounted to 995,589 tons, of which 550,818 tons came from the Witbank mine and 444,771 tons from the Uitspan mine. The total was 127,734 tons higher than that for the previous year, and was the highest recorded in the history of the company. The profit for the year was £96,750, out of which £61,250 was distributed as dividend. During the year, £140,000 of the accumulated profit, used in the business, was capitalized, and 140,000 shares were distributed as a bonus to shareholders. The capital of the company was thus raised from £210,000 to £350,000.

Taquah Mining & Exploration.—This company was formed in 1888 as the Taquah & Abosso Gold Mining Co., to acquire gold-mining properties in Gold Coast Colony, West Africa. In 1901 the company was split, the Abosso mine being transferred to a subsidiary company. The report for the year ended June 30 last shows that 53,844 tons of ore was sent to the mill, and that the total yield of gold was 32,907 oz. The par value of the gold was £139,550, and the premium brought the total receipts up to £173,879. The working cost was £109,544, and allowance for depreciation £27,782, while £13,317 was received as dividends and profits on sale of shares. The net profit was £51,129, out of which £48,434 was distributed as dividend, being at the rate of 12½%. The ore reserve was estimated on June 30 at 182,226 tons averaging 52s. 6d. par value. Labour shortage has interfered with development. The lode turns upward at the 14th level of the internal shaft. This has been followed for 250 ft., and its further continuance is now being tested.

Abosso Gold.—This company is a subsidiary of the Taquah, particulars of which are given in the preceding paragraph. The report for the year ended June 30 last shows that 82,588 tons of ore was treated, averaging 37s. 8d. in gold per ton par value. The yield of gold was 33,555 oz., worth £142,310 par value, or with the premium £177,735. The net profit was £50,039, out of which £50,000 was distributed as dividend, being at the rate of 12½%. Developments continue to be satisfactory, and the reserve at June 30 was calculated at 300,000 tons averaging 34s. 6d. par value. The shortage of available labour is a serious question at present. During the year the property of the Wassau (Gold Coast) Mining Co. has been purchased for £20,000. This property consists of mining areas on the dip of the Abosso and of timber concessions near by.

Prestea Block A.—The report of this company, operating a gold mine in West Africa, for the year 1919, just published, shows that 181,398 tons of ore was milled for a yield of gold selling for £330,090, of which £29,222 came from premium. The yield per ton was 36s. 4d. The working cost was £297,657, or 32s. 9d. per ton, and allowance for depreciation £25,605. The ore reserve at December 31 was estimated at 317,350 tons averaging 38s. 8d. per ton, as compared with 469,645 tons at the end of 1918. The newly discovered ore-body north of Prestea shaft is giving good results, and the average assay-value is higher than that of the ore reserve. The length of the pay-shoot on this ore body is greater on the 12th than on the 11th level, but on the 13th level the results are not so satisfactory. Owing to the bad nature of the ground in Prestea shaft, the development of the lower levels is to be done by an auxiliary internal shaft. The mine has suffered greatly by shortage of labour, as have all other mines in West Africa.

Northern Nigeria (Bauchi) Tin Mines.—This company was formed in 1910 to acquire alluvial tin ground at N'Gel in Nigeria from the Anglo-Continental Mines Co. An account of the property was given in the MAGAZINE for February, 1918, and in March, 1920, particulars were given of the hydro-electric installation in course of erection. The report for the year ended June 30 last shows that the output of tin concentrate was 465 tons, an increase of 100 tons as compared with the previous year. Of the total, 268 tons came from the Gona section. The profit was £14,150, out of which £10,039 was distributed as dividend on the preference shares. Additional properties and licences have been acquired, and much exploratory work has already been done. Altogether ground estimated to contain 1,876 tons has been proved, bringing the total contents of the proved ground to 9,797 tons. The construction of the new plant is progressing, but owing to increases in the price of materials the cost will be much greater than originally contemplated, and a further £125,000 will be required. Negotiations are at present in hand for the raising of this amount.

Jantar Nigeria.—This company was formed in 1912 to work alluvial tin ground near Naraguta, Nigeria. The report for the year ended September 30 shows that 143 tons of tin concentrate was extracted, as compared with 110 tons and 166 tons during the two preceding years. In addition to the income from sales there is an item in the accounts of £4,100 as returned excess profits duty, which had the effect of converting a deficit on working into a profit balance of £838. Owing to labour shortage it has been impossible to work the new properties recently acquired. As recorded last month, the company is being amalgamated with the Kuru South and the Kuru Syndicate.

Dua (Nigeria) Tin Fields.—This company was formed in 1902 to acquire mining rights in Bauchi Province, Nigeria. In 1907 it acquired the properties on the Jarawa, previously owned by Mertens, of Hamburg, and also properties on the Juga river at Sutumi. J. H. Cordner-James is the chairman. The report for the year ended June 30 shows that the output of tin concentrate was 46½ tons. The receipts were £10,787, and the expenditure £15,260, leaving an adverse balance of £4,473. The Sutumi property has proved to be a great disappointment. Parts of the Jarawa property also have given similar adverse results, while the parts containing tin would require considerable expense for pumps to give an adequate water supply. Under existing conditions the directors do not consider such expenditure warranted.

Menzies Consolidated Gold Mines.—This company was formed by C. Williamson Milne in 1895 to acquire gold-mining properties at Menzies, West Australia. R. Goninon is manager. The capital is £224,015, and the only dividends paid were distributed for the four years 1914 to 1917, when 2½% per year was paid. The report for the year ended July 31 shows that 19,909 tons of ore was milled, yielding 10,080 oz. of gold bullion, by amalgamation, cyaniding, and concentration. This gold was sold for £52,332, of which £12,927 represented premium. The net profit was £3,231, which was carried forward. Development has given unfavourable results during the year, and the ore reserve has declined. The shaft has been sunk to 1,933 ft., and a 19th level is to be opened. The future of the mine will depend on the results obtained.

Yuanmi Gold Mines.—This company has been working the Yuanmi gold mine in the East Murchison goldfield, West Australia, since 1911. Dividends were paid in 1913 and 1914, but afterward developments gave poor results. A year ago conditions became more hopeful. In order to raise additional capital, 500,000 preference shares at 2s. each were created, and of these 220,000 have been issued so far. The report for the year ended June 30 last shows that labour conditions have prevented any comprehensive scheme of development being undertaken. In fact the shortage was such that the treatment operations were suspended for several periods totalling three months. Owing to faults and dykes the ground is not easy to prospect. During the year 14,922 tons of ore was treated, yielding gold which sold for £57,920. The expenses were greater than the income by £2,013.

Sulphide Corporation.—This company owns the Central lead-zinc-silver mine at Broken Hill, a lead smelter at Cockle Creek, near Newcastle, New South

Wales and a zinc smelter at Seaton Carew, County Durham. The mine was idle during the year ended June 30 last covered by the report now issued. On the exhaustion of stocks, the Cockle Creek smelter was closed at the end of 1919. During the six months it was working, 15,885 tons of mine and custom ore was smelted for a production of 3,849 tons of lead bullion containing 5,802 oz. of gold and 503,493 oz. silver. At the refinery there was produced 3,597 tons of soft lead, 207 tons of antimonial lead, 8,333 oz. gold, and 664,407 oz. silver. At the sulphuric acid plant the production was 13,[illegible] tons, and at the superphosphate plant 17,398 tons. The Central zinc works at Seaton Carew was occupied in treating zinc material that had been purchased by the British Government, including some from Australia. The amount of roasted concentrate smelted was 8,362 tons, from which was produced 2,817 tons of spelter, 13 tons of zinc dust, and 17 tons of lead. The residues, 6,316 tons, were too low in lead and silver to warrant treatment, with the exception of 336 tons, which was concentrated for a yield of 67 tons of leady material. The company's accounts show a balance of profit of £32,394, but it was not possible to distribute a dividend.

Fremantle Trading.—This company was formed as the Western Australian Smelting Co. in 1897 to erect a smelter and to work lead mines in the Northampton district of West Australia. A description of the property was published in the MAGAZINE for March, 1919. The mines were reopened in February, 1920. The report for the year ended July 31 shows that at the Baddera mine 2,978 tons of ore yielded 506 tons of concentrate averaging 72% lead; at Narra Tarra, 8,406 tons of ore yielded 975 tons averaging 70·9%; at Wheal Ellen, 208 tons of ore yielded 44 tons averaging 71·6%. At the smelting works 1,134 tons of ore and concentrate was treated for a yield of 579·6 tons of soft lead, which was sold at an average price of £40. 16s. per ton. The accounts show a profit of £2,378, which was carried forward. The labour position and the low price of lead make it uncertain how long operations can be continued.

Chinese Engineering & Mining. — This company was formed in 1900 to acquire coal mines at Kaiping, in the State of Chi-li, north China. It was reconstructed in 1912 in order to effect a working arrangement with the Lanchow company, a Chinese-owned company operating in the same neighbourhood. The businesses of these two companies are now controlled by the Kailan Mining Administration. The report for the year ended June 30 last shows that the sales effected by this Administration during the year were 4,010,980 tons of coal, an increase of 882,303 tons as compared with the previous year, and the net profit was $8,917,456, of which the Chinese Engineering & Mining Co.'s share was $4,581,804. The net profit of the company was £1,112,412. Out of this, £524,702 has been placed to reserve for excess profits duty, and £300,000 has been distributed as dividend, being at the rate of 30%. It is proposed to capitalize £400,000 of the accumulated profits. For this purpose the nominal capital is to be increased from £1,000,000 to £2,000,000, and after the 400,000 new shares are issued, 600,000 will be available for issue whenever desirable. The reason for this provision of further capital arises out of a project for establishing an iron industry. The company and the Lanchow company have acquired an iron ore deposit on the Yangtse River, reported by Frank Merricks to contain 4,000,000 tons of high-grade ore. It is proposed to build a smelter at the port of Chinwangtao from plans prepared by F. W. Harbord.

Cape Copper.—This company was formed in 1863 to work copper mines in Little Namaqualand, Cape Province. The ore and matte were brought to Briton-ferry, South Wales. More recently copper mines in Rakha Hills, Chota Nagpur, India, have been developed. The report for the year ended August 31 shows that mining operations are still in abeyance at the Cape, having been discontinued in May, 1919, owing to the adverse copper position. The mines are being kept in working order, and an extensive drilling campaign is in hand for the purpose of prospecting adjoining properties at Koperberg and Carolusberg. The metallurgical plant at Rakha Hills had not been finally completed during the year under review, so that the actual output of copper was small, but since the issue of the report a full output of 250 tons of copper per month had been reached. Some of the stocks at the Cape have been sold in New York, and the remainder has been treated at Rakha Hills. During the year, 35,540 tons of ore averaging 3·57% copper was mined at Rakha Hills. The reserve is estimated at 354,688 tons averaging 3·66% copper. The company's accounts for the year show a deficit of £163,627, owing to the virtual suspension of sales. As recorded last month, the company has made provision for further capital by the issue of £120,000 debentures.

Tolima.—This company was formed in 1871 to acquire the Frias silver-lead mine in Colombia. In the early days the operations were highly profitable, but in 1903 and 1909 reconstructions were necessary. During the war great difficulty was experienced in shipping the concentrate and getting it smelted. The report for the year ended June 30 last shows that 7,259 tons of ore was raised and concentrated, yielding 607 tons of concentrate averaging 453¾ oz. silver per ton and 14·87% lead. This material was sold for £63,530. The accounts show an adverse balance of £4,087 for the year. The ore reserve is estimated to contain 1,361 tons of shipping material. During the year there was a brief strike, which led to an increase in miners' wages of 25%. This and the continued rise in the cost of materials makes profitable mining increasingly difficult.

Frontino & Bolivia Gold. — This company was formed in 1864 (being reconstructed in 1886 and 1911) to work a group of gold mines in Colombia, the principal property being the Silencio mine. Pellew-Harvey & Co. are the consulting engineers. The report for the year ended June 30 last shows that 29,760 tons of ore was treated, giving by amalgamation and cyaniding a yield of 25,815 oz. of gold. The profit was £28,161, out of which £4,513 was paid as debenture interest, £2,339 as preference dividend, and £14,000 as ordinary dividend, at the rate of 10%. Labour conditions have prevented the mine from being worked at full capacity. Developments at the lowest level, the 16th, have been good, and the reserve has been slightly increased, standing now at 65,600 tons averaging 16 dwt. per ton. The company has a half share in the Marmajito Mines, Ltd. The plant for unwatering and developing this property has been despatched.

Berenguela Tin Mines.—This company was formed in 1905 to acquire lode-tin properties at Berenguela, Bolivia. Particulars were given in an article in the MAGAZINE for December, 1914. The report for the year ended June 30 last shows that the output of tin concentrate was 386 tons, as compared with 366 tons the year before. The gross trading profit was £41,521, and, after the placing of £14,751 to reserve for contingencies, the net profit was £25,125. Out of this profit, £10,000 has been placed to general reserve, and £10,000 has been distributed as dividend, being at the rate of 25%.

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EDITORIAL

A writer in the *Engineering and Mining Journal* of New York estimates the output of gold throughout the world during the year 1920 at £6[illegible],700,000, par value, as compared with £75,000,000 in 1919, and £79,000,000 in 1918. The highest total ever recorded was £98,000,000 in 1915. He reports that the condition of gold-mining in the United States is far from satisfactory, for there is no premium on the metal, and prices of labour and commodities have increased enormously.

A MODEL of the surface plant at the south shaft of the New Modderfontein gold mine has been prepared by the Central Mining & Investment Corporation, under the direction of Mr. H. F. Marriott, and it is now on exhibit at the London office of the company, No. 1, London Wall Buildings. It is to be shown at various places in this country and on the Continent, and it is suitable for the instruction of both the public and the mining student. This plant is an excellent example of latest Rand hoisting and metallurgical practice, and the model is well worth inspection.

IN this issue is published the first half of an article describing the principle of transmission of power by waves of water-compression, and its application in practice, particularly to rock-drills. We have purposely split the article in two, so that readers shall obtain a grasp of the principle before trying to understand the action of the machines. The principle is so novel, and its action in rock-drilling is of such an unaccustomed nature, that engineers will probably take some time to obtain a full grasp of the subject. Next month we intend to say more of the possibilities of the drill. In the meantime it is sufficient to mention that the drill is a practical machine and that several are already at work in mines and quarries.

FIVE years ago Mr. Reginald Le Neve Foster endowed the Royal Society of Arts with a small fund in memory of his father, Peter Le Neve Foster, who was secretary of that society from 1853 to 1879, the proceeds of the fund to be devoted as prizes for the best papers on current subjects of importance. The first offer of the prize was for a paper on the metallurgy of zinc, and the best of those submitted were by Mr. J. C. Moulden and Mr. E. A. Smith. The society now announces a second competition under the terms of the benefaction. This time the subject is the Mineral Resources of China, a subject open to considerable discussion, for opinions vary widely. There are many engineers well qualified to give the records and their views as to the future. It is to be hoped that they will respond to the invitation.

PARTICIPATION in the direction of mining companies is not usually a congenial occupation for a lady, but every now and then opportunity is afforded for the exercise of conspicuous ability in the conduct of mining business. Lady Rhondda is a director of a dozen South Wales colliery companies, and many readers will remember Mrs. Kermode, a director of the Tasmanian Metals Extraction Company. This month the appointment of Mrs. H. J. Tennant to the board of the Champion Reef Gold Mining Company of India is announced. Before her marriage to the son of the late Sir Charles Tennant, she was, as Miss Abraham, the Superintending Inspector of Factories in England, and achieved a distinguished success in that position.

PRECEDENT dating from 1776 interdicts the reference by an Englishman, approvingly or otherwise, to the appointment or candidature of any individual for a public position in the United States. For this reason we refrained from making any comment on Mr. H. C. Hoover's chances of becoming president, and even now it is impossible for us to discuss the outlook for his becoming a member of Mr. Harding's administration. Probably also it is out of order for us to congratulate the United States on the appointment of Mr. H. Foster Bain to the directorship of the Bureau of Mines; but as this is not in the nature of a political position, we feel justified in breaking the time-honoured custom. Mr. Bain is well known throughout the world as an alert geologist and mining engineer, one with an open mind, one desirous of making friends without restriction as to nationality or position. For a few years he edited the *Mining and Scientific Press*, and subsequently he was editor of THE MINING MAGAZINE for a short time. His travels have taken him to many places outside his own country, South Africa, Rhodesia, the Congo, the Malay Peninsula, Burma, China, and Japan. In his new position he will be occupied with much congenial work, and his "soul will not be fettered to an office stool."

Standardization of Mining Materials.

At the meeting of the Institution of Mining and Metallurgy held last month, a subject of considerable interest to the mining profession was introduced by a paper presented by Mr. E. A. Wraight, on the Standardization of Materials employed in Mining and Milling Plant. In order to avoid a misconception as to the scope of the paper, it should be said at once that this discussion relates only to materials employed and not to the design and construction of plant. This latter subject has been to the forefront in certain quarters in the United States recently, where proposals have been made for the evolution of standards for all machinery, beginning with motor cars and including mining machinery and supplies. Mr. Wraight's proposals are confined solely to a discussion as to the best materials for each particular purpose required. This subject has seldom received serious discussion and experimentation, and the reasons are not difficult to recognize, as far as non-ferrous metal mining is concerned. In the first place the persistence of ore is such an uncertain factor in the economics of mining that an engineer or director is seldom warranted in conducting tests or subscribing money to that end. Then again, the conditions of work vary so widely that accurate comparisons are difficult to make. Where the requirements are clearly ascertainable, the funds at disposal unlimited, the labour highly skilled, and competition severe, it is possible and necessary to specify the exact nature of the material to be used for every separate component of the machine. These conditions are not often found in mining. Another difficulty arises from the fact that non-ferrous metal mining is a comparatively small industry. For instance, the Sheffield firms produce special steels suitable for rock-drill purposes, for the wearing faces of ore crushers, and for stamp shoes and dies, but the proportion of their production of steel for these particular purposes is very small compared with the total output of the works, and it is consequently impossible to ask them to make the investigations desired.

Mr. Wraight's paper dealt with drill steel, component parts of stamp-mills, balls and linings for re-grinding mills, facings for Cornish rolls, etc. Even his short statement was sufficient to indicate the bewildering complication of the subject. In the discussion following the presentation of the paper, Mr. Robert Allen gave a brief outline of the work he did in connection with drill steels for the Johannesburg Mines Trials Committee, particulars of which were published in the MAGAZINE for July, 1913; and the subsequent speakers confined their remarks entirely to this branch of the subject. Mr. F. W. Harbord and Professor Carpenter, as leading authorities on the metallurgy of steel, gave their views as to the nature of the steels required for drilling purposes and the behaviour of such steels under forging and sharpening. They considered that theoretically three or more standards would be required, according to the hardness of the rocks, and they doubted whether the expense of such special steels would be warranted unless the smiths in charge of sharpening were fully equal to their work. The general impression obtained from the discussion was that mining operations cannot profitably demand very accurate metallurgical distinctions as regards the steels used, and that better results from the economic standpoint can be obtained with steels having wider ranges of applicability. The discussion at the meeting concluded with a general recommendation that the various mining societies might appoint committees to consider these subjects, and make investigations and suggestions, but it is doubtful whether anything definite can be done in this direction.

Oil on the Waters.

Oil-fuel for steam-raising on board ship presents a good many advantages, as is well known. Absence of smoke during the voyage and of dust during coaling, the rapidity with which the supply of fuel can be taken on board, the great reduction in the number of men required in the furnace rooms, and the ease with which the vessel can be kept in trim all favour the employment of oil-fuel. One of the most serious drawbacks, however, is that the supply of this type of fuel is not unlimited. Reference has already been made in these pages to Admiral Dumas' protests against its indiscriminate use. Since then, one of the leading shipbuilders, Lord Pirrie, head of Harland & Wolff, has also uttered a public warning to the shipowners, telling them that, even at the present rate of consumption, the available supply will come within very narrow compass in twenty years, and that if this method of steam-raising is at all widely expanded the world's resources will be drained long before then. The evil day will, of course, be postponed by the use of the colloidal fuel now being developed by Minerals Separation, seeing that about a quarter of the oil employed in this way will be replaced by fine coal. For this reason the shipping people ought to

pay close attention to the new process. To attempt to induce the shipowners to go slow on oil would be a fatuous proceeding, for, according to the laws of business, profits must always be made when opportunity arises and when good engineering work can be done. In any case it is not a difficult matter to make alterations in the furnaces when it becomes necessary to revert to coal, and moreover it is always possible that a method will eventually be devised whereby fine coal dust can safely be used on board ship without any admixture of oil.

The foregoing considerations with regard to the use of oil-fuel at sea are already well known to engineers, and reference to them is made now only for the purpose of emphasizing the position. A new objection to oil, however, has recently been widely ventilated in the press, and this deserves careful examination with a view to ascertaining the extent of its truth. It is alleged that the oil escaping from the ships has a deleterious effect on marine life, and that as a consequence the fishes and birds stand in danger of extermination. It is alleged that the leakage of oil both from tankers and oil-driven steamers is gradually covering the surface of the sea with a film of oil, of infinitesimal or molecular thinness certainly, but nevertheless sufficient to prevent the aeration of the water and thus check the growth of marine life. The destruction of submarines and the wreck of ships also account for the release of much oil. Another cause of oil getting access to the surface of the sea arises from the practice of filling empty oil tanks with water ballast, and afterwards pumping out the water when the tanks have to be re-charged. This last-named proceeding causes an unpleasant fouling of harbour waters. The first to call public attention to this unfortunate state of affairs was Sir Arthur Quiller-Couch, who uttered a powerful protest against the filthy condition of the roadstead at his beloved Fowey. Anyone who visits the ports patronized by oil-ships can see for himself the unpleasant nature of the surface of the waters, and it can hardly be disputed that in the harbours, and in the approaches by sea toward them, the conditions are distinctly unsatisfactory. It is an open question, however, whether the ocean highways suffer much pollution from the passage of the oil-ships. In fact, they probably suffer less from oil-ships than from coal-ships. With ordinary coal-burning ships, oil escapes into the sea-water circulated through the condensers, while the products arising from the incomplete combustion of the coal, namely, soot, ammonia, acids, and a multitude of organic compounds, eventually reach the water. So the defilement of the track of civilization is not due solely to this new class of offender. There are many other possible causes for the disappearance of fish from our shores than the pouring of oil upon the waters. For instance, vast amounts of imperfect explosives and other chemicals have been dumped in the seas by order of the Government. Then also works and factories on the rivers and sea-board discharge some sort of effluent directly into the sea, and are in fact encouraged to deliver their refuse far out. The authorities are, of course, keen that rivers should not be polluted, but they are not concerned with what happens beyond the limits of the sea-shore. Taking everything into consideration it seems to us that this case against oil is not particularly strong, except from the point of view of the condition of the harbours where oil-ships resort. The Government and the local authorities are competent to deal with this matter. As for the fouling of the open seas, it will be well if it were possible for some scientific body to make an impartial investigation so that the supposed or actual damage can be traced to its ultimate source.

Kirkland Lake.

One of the most important geological reports issued recently is that on the Kirkland Lake gold area, Ontario, made by Messrs. A.G. Burrows and P. E. Hopkins for the Ontario Bureau of Mines. The first section of this report, dealing with the geology and the ore deposits, is published in the Mining Digest elsewhere in this issue, and the remainder, describing the individual mines, will appear in subsequent numbers. Like most of the official technical documents published in Canada, it is up to date and helpful for the present purposes of the prospector and miner. It will be remembered that the same two geologists made a report on the district in 1912, shortly after the first discoveries were made. Thus the pioneers have continuously had every assistance from the Government, and many useful hints for future work have been provided by disinterested parties. Readers of the MAGAZINE will have followed the rise of this centre of gold production, for without intermission news has been published regularly since 1913. In the early days, Mr. Reginald E. Hore, editor of the *Canadian Mining Journal*, gave a comprehensive account, and Mr. J. B. Tyrrell contributed a paper on the subject to the Transactions of the Institution of Mining and Metallurgy. These

authors were followed by Mr. Charles Spearman, who discussed the nature of the ore minerals. For the benefit of those who are not familiar with this district and its history a few notes at this juncture may be given. In reading these notes reference should be made to the maps accompanying the report and reproduced in the Mining Digest.

The Kirkland Lake area forms part of a large mineralized region which extends from Matachewan north-easterly through Larder Lake and into the province of Quebec. There was a gold rush in 1906 to Larder Lake, and during that time many claims were staked at various points between that lake and the railway at Swastika. The Larder Lake boom did not yield any substantial mining success and the district was soon deserted. On the other hand, a property at Swastika, and subsequently an adjoining property known as the Lucky Cross, proved profitable. These successes and the concurrent progress at Porcupine served to draw attention once more to this area. The first gold discovery at Kirkland Lake was made in 1911 by Mr. W. H. Wright, who staked out claims which are now parts of the Wright-Hargreaves mine. By the end of that year nearly the whole of the ground was re-staked. Early in the next year gold was found on the Tough-Oakes claims to the north-east of the lake. These early discoveries did not reveal any particularly attractive ore, and it was not until 1913 that rich ore found on No. 2 vein of the Tough-Oakes workings brought the district into prominent notice. During that year much surface trenching was done, and a number of promising veins were found on the Burnside, Sylvanite, Wright-Hargreaves, Lake Shore, Teck-Hughes, Orr, Kirkland Lake, and Hunton claims. At first the ore raised at the Tough-Oakes was hand-sorted, and the picked ore sold to smelters. As an indication of the nature of the ore it may be mentioned that during 1914 the assay-value of the ore mined was $41 per ton; the amount of high-grade ore shipped was 212 tons, averaging $350 per ton, while a 5-stamp mill treated 3,493 tons, averaging $22 per ton, extracting 55% of the gold content. In 1915 capital was provided for the erection of a treatment plant on the continuous cyanide system, having a capacity of 100 to 125 tons per day. During the year 1916 this plant extracted gold worth $700,000. In this year also a mill was built on the Teck-Hughes mine, working on much the same system as that at the Tough-Oakes, but at this property the average assay-value of the ore is much lower. During this time development was continued at the Lake Shore, and in 1916 work was commenced on the Wright-Hargreaves and the Kirkland Lake properties. Toward the close of 1917 mills were built for the Lake Shore and Kirkland Lake. In 1918 the Tough-Oakes mine was closed owing to the developed ore being exhausted and no development having been done, but mining operations were resumed next year in conjunction with the Burnside. In 1919 three mills were in operation at the Kirkland Lake, Lake Shore, and Teck-Hughes, while mills were being built on the Burnside and Wright-Hargreaves. During these latter years there were many interruptions owing to scarcity of labour, high wages, and increased cost of supplies, and a strike of four months' duration also supervened. The district has also suffered owing to disputes relating to the transfer of ownership of some of the properties to an English company, the Kirkland Lake Proprietary. These difficulties were fortunately overcome a little over a year ago by the amalgamation of that company with the English Tough-Oakes, Sylvanite, and Burnside companies, and a new campaign of development has been commenced.

It is expected that the yield of gold during 1920 will be worth about a million dollars. This may seem small compared with the output at Porcupine, but nevertheless the importance of the Kirkland Lake district is considerable. The lodes are plentiful, and in places the ore-shoots are rich. Further prospecting promises to give excellent results through a large area of country in all directions. As will be seen by a perusal of Messrs. Burrows and Hopkins's report, the gold, accompanied by tellurides, is found in an extensive series of fractures. This fracturing crosses all the rocks, which include felspar-porphyry, syenite, lamprophyre, and conglomerate. The gold is most plentiful in lodes contained in the porphyry, and it is probably genetically connected with that rock. It is clear from the geological description that the Kirkland Lake district will well repay further and continuous investigation

Libel and Criticism.

Last month brief notice was made in these columns of a pronouncement made by the Lord Chief Justice, in the course of a libel suit, to the effect that he felt impatient when he was told that the offending articles were written as a public duty, adding: "You did it in the ordinary course of business." Such an expression of opinion coming from the head of the English Bench is, to say the least, disconcerting, and is likely to make an editor feel and

look small when confronted with the majesty of the law. Seeing that the policy of the MAGAZINE has always been to express opinions freely, it is clear that we come within the scope of the Lord Chief's dictum, and for that reason several readers have asked us for a definite statement as to our general views with regard to criticism and libel. We would say, to begin with, that all personal criticism is repugnant to us and to 99% of the technical editors of the world. In the first place, it makes enemies and brings no new friends; and secondly, a libel action distracts the editor's attention from his proper occupations and involves him and the proprietors in unlimited legal expenses. Thus from both points of view it is not "business." Here it should be observed that we are concerned only with libel in technical publications, and that the offending journal appearing in the Lord Chief's court was devoted to a branch of engineering. It is necessary to call attention to this fact, for it is well known that certain types of popular papers welcome libel suits as they afford means for securing publicity and advertisement. Moreover a personal libel is often associated with blackmail, and as such constitutes one of the most unsavoury phases of evil-doing. It is possible, of course, that the Lord Chief saw no distinction between these two classes of libel, and that he would not even recognize the possibility of such a distinction. The fact is that most lawyers of good standing do not particularly relish the duty of defence in a libel action, however great may be the integrity of the author of the alleged libel. Their attitude on the subject, both physically and mentally, is usually reminiscent of Mr. Pickwick's famous interview with Serjeant Snubbin. "Mr. Serjeant Snubbin unfolded his glasses, raised them to his eyes, and, after looking at Mr. Pickwick for a few seconds with great curiosity, smiled slightly as he spoke. . . . The smile on his countenance became more defined, and throwing himself back in his easy chair, coughed dubiously. . . The serjeant tried to look gravely at the fire, but the smile came back again."

From the foregoing remarks it is obvious that irritant criticism is not a "business" proposition for an editor of a technical journal. On the other hand, the editor has to think of the honour and reputation of the profession which his paper seeks to represent. Mining is unfortunately not free from public reproach, and in some quarters it is even classed with gambling and swindling. Thus it is incumbent on the editor of a mining paper, in the way of "business," to say something in protest when mining propositions resting on insecure foundations are placed before the public, for, when ventures of this character collapse, it is usually mining and the mining engineer that are blamed, and not the organizers of the schemes. Thus, in spite of his repugnance, the editor has to imagine that it is his duty to his profession and to the public to point out the absence of any real basis for such ventures. But it is impossible to embark on such an attempt at exposure unless there is ample confirmatory evidence of the unsoundness of the ventures in question. It would surprise our readers to know how many grievances are brought to our notice which are not suitable for public comment. Some of them are real enough, but the faults are often due more to lack of personal judgment than to evil intent, while others are not substantiated by evidence acceptable in a court. Comment could never be made by an editor on any grievance that rests on a difference of opinion between two members of the profession, or on any allegation against a member of the profession made by an outsider. Such matters are not of public interest, and adjudication on them rests entirely with the Council of the Institution.

There is another point of view in connection with the presumed "public duty" that remains for consideration. After an editor has persuaded himself of this public duty, the question usually arises within his mind as to whether the public will ever thank him for drawing attention to the lack of basis for a particular venture. On the failure of the properties, or on the exposure of their barrenness, the shareholders find their shares unsaleable, or saleable only at an absurdly low price, and their attitude of mind is naturally bitter. The editor who issued the warning is an unpopular person, for he has knocked down the house of cards, and has prevented the shareholders from realizing their shares, and he is certainly unable to offer them any solatium. On the other hand, the promoter or the board may be often in a position to help the shareholders to retrieve a part at least of their losses. In any case the average subscriber to mining shares does not read the technical mining papers, so it seems little use from the "public-duty" point of view for such papers to utter these warnings. Thus we are faced with the conclusion, which seems like a reductio ad absurdum, that, whether considered from the point of view of "public duty" or of "business," libel and criticism do not pay. Nevertheless, a spice of criticism partakes of the nature of an imponderable asset, which, though indefinable, is none the less real.

REVIEW OF MINING

Introduction.—The world is now passing through a serious trade crisis. Metals are quoted at prices a long way below the average cost of production, and stoppages, partial or total, are announced in many quarters. The position of the Cornish tin industry is very serious, for hardly any actual mining is being done. The gold industry exists largely on the premium at present obtainable. In business circles there is gratification at the forthcoming withdrawal of the Excess Profits Duty, though the real reason for the change of front on the part of the Government is gloomy enough.

Transvaal.—The output of gold in the Transvaal during the year 1920 amounted to 8,153,625 oz., as compared with 8,330,091 oz. in 1919 and 8,418,292 oz. in 1918. In 1912, 1915, 1916, and 1917, the totals exceeded nine million ounces, and the highest figure was 9,296,618 oz. in 1917. The par value of the 1920 output was £34,652,700, but owing to the premium the value of the gold was estimated at £44,640,420. It will thus be seen that approximately £10,000,000 was received as premium. When it is added that the dividends declared during the year amounted to £8,314,300, it becomes clear how much the Transvaal gold-mining industry depends on the premium for its profits.

The new Currency Act of the Union came into force on December 17, and so far the mail accounts show that the disappearance of the gold coins has been accepted without complaint or comment. The attitude of the natives toward paper money was carefully considered before the change was made, and the supply of silver coin was increased so that as far as possible native wages should be paid in hard cash. In some quarters the substitution of paper for gold gave rise to uncertainty among the natives, but the position was so fully explained by the Government and by the various employers that there was no serious trouble. The authorities have handled the matter with much more common sense than was shown by those responsible for paper money in West Africa.

A strike of white miners has put Consolidated Langlaagte out of action for the time. The cause is imperfectly understood in this country. There are rumours that the men's Union contemplate a general strike, but this may be only a ruse in connection with the elections. At the time of going to press little definite news has come to hand.

The directors of Modderfontein East have completed the negotiations, to which reference was made in the December issue, for the purchase of the Simmer Deep and Jupiter milling plant. The figure agreed to is £110,000. The capacity of the plant as it stands is 80,000 tons per month, but only 50,000 tons is to be treated at Modderfontein East.

No. 4 vertical shaft in the new section of Brakpan has reached the reef at a depth of 4,218 ft. The average of the assays gave 7·6 dwt. over 39·2 in. The foot-wall leader, included in the foregoing measurement, averaged 15·3 dwt. over 18·4 in.

The ore-reserve position at Geduld continues to show advances. The figures at December 31 were estimated at 3,220,000 tons averaging 8 dwt. per ton, as compared with 2,580,000 tons averaging 7·4 dwt. the year before, in both cases the stoping width being assumed at 61 inches.

Brief mention is made in the directors' report of the Messina company, and in the chairman's speech at the meeting of shareholders, of the new project for establishing a copper smelter and refinery to treat the ores produced at the company's mines. The building of this plant is in the hands of a new company, the Transvaal Smelting & Refining Co., Ltd. Its business will not be confined to the smelting of the Messina ores, for it is intended also to purchase copper ores from mines now being opened up in the same district. The Messina mines were closed some months ago owing to continued rises in costs and the fall in copper, and the labour force was transferred to the erection of the company's new concentrating plant and of the smelting company's furnaces. Mining will not be recommenced until the new plants are ready.

Rhodesia.—The output of gold during the year 1920 was 552,498 oz. and the estimated amount obtained by its sale was £3,056,549. This figure is really slightly higher than it should be, for in May there was included among the receipts an unspecified amount representing premium on the outputs during October, November, and December, 1919. At present the biggest producers are the Shamva, Lonely, Falcon, and Globe & Phœnix, of which the first two exhibit the healthiest symptoms as regards the future.

The British South Africa Company has issued figures for the output of metals and minerals in Southern Rhodesia during 1920.

These are given in the following table, together with the figures for 1919.

		1919	1920
Gold	Oz.	593,222	552,497
Silver	"	172,000	158,982
Copper	Tons	3,012	3,109
Chrome Iron Ores	"	35,282	60,269
Asbestos	"	9,799	18,823
Coal	"	510,040	578,492
Tungsten Ores	"	20	17
Arsenic	"	242	437
Antimony	"	--	11
Ironstone	"	2,500	—
Mica	"	6	97
Tin	"	4	4
Diamonds	Carats	385	243

The market value of the gold produced in 1920 is given at £3,056,549, as compared with £2,499,498 in 1919. Though the output was 39,000 oz. less, the amount received by the mines was £557,000 greater, owing to the premium ruling for gold.

The Lonely Reef continues to give good results in depth. On the 24th level the ore is found to assay 39·9 dwt. over 44 in., and development of this level has been started.

The Cave Commission has at last presented its report as to the amount due to the British South Africa Company for administration expenditure on behalf of the Crown. The company claimed the amount of £7,866,117 up to July, 1919. Against this, the award of the Commissioners is £4,435,225 up to the end of March, 1918, but a good many items based on valuations may have to be reargued.

The desire of the residents in Rhodesia for responsible self-government has been before Lord Milner, Secretary of State for the Colonies, for some time past owing to the result of the election to the Legislative Council in April last of twelve out of thirteen members pledged to demand the immediate grant of this form of government. Lord Milner recommends that this question should be postponed until the election in 1923. Owing to the charter of the British South Africa Company expiring in 1924, it is clear that the future government of the country will then come up for consideration, and the elections for the council in 1923 would naturally be the proper time for registering public opinion. Lord Milner, in the meantime, proposes that for the next three years the British Government should advance certain sums required for public works, owing to Rhodesia not being in a position to raise loans in the open market. The members of the council do not accept these proposals for delay and have addressed Lord Milner once more on the subject.

Congo.—An outline of the yearly report of Tanganyika Concessions, together with a new official map of Haut Katanga, are given elsewhere in this issue, as is also Mr. Robert Williams' speech to shareholders. The most interesting item of news relates to the formation of the Nile-Congo Divide Syndicate, which has secured an 80% interest in certain mineral rights in the Sudan along the Nile-Congo watershed. The syndicate has a capital of £35,000, of which Tanganyika Concessions has subscribed £10,000, with an option to take up 5,000 more shares within five years. The leading spirit in this enterprise is Major Christy, who, together with Mr. Robert Williams, has had evidence for some time that the region would repay prospecting for minerals. It will be remembered that the north-eastern part of Congo State, which is also on this watershed, contains a number of rich gold deposits.

West Africa.—The Prestea Block A company reports that the main ore-shoot is showing serious signs of exhaustion. The only recent accession to reserves was in a length of 90 ft. on the 12th level between the North and the Appantoo shafts, averaging 44s. over 110 in. A winze is being sunk to ascertain how far the ore continues downward. On the 11th level a newly discovered shoot is being developed, where the ore averages 45s. 6d. over 107 in. for a distance of 310 ft. On the 12th level the ore averages 37s. over 126 in. for 635 ft. The immediate future of the mine depends on how this shoot develops in length and breadth.

Nigeria.—The persistent slump in tin is giving most of the producing companies an anxious time. Not only is the price low, but sales are not promptly effected, so that the financial position of most of the mines is by no means secure. As regards the issue of £25,000 debentures by the Jantar company, announced last month, the response has been so poor that the issue has been withdrawn, and orders have been given to cease work at the properties at the end of April unless the tin market substantially revives.

Australia.—The Broken Hill industry is fated to receive one set-back after another. The latest disaster is the burning of part of the Associated Smelters' plant at Port Pirie, the sintering section being the chief sufferer. It is estimated that damage to the extent of £100,000 has been done. The official cable states that the question of replacement and the erection of temporary plant for use in the meantime is receiving the consideration of the board.

The position at the Broken Hill mines remains obscure. It is obvious that the discussion on reduction of work owing to low prices of metals is now complicated by the fire at Port Pirie. The Zinc Corporation announces that mining is to be stopped at the South Blocks,

and that the only material to be treated is the old zinc tailing. It will be possible to realize on the zinc concentrate produced, for the British Government is still bound by the contract to purchase such concentrate for 10 years from 1916.

The railway strike which caused the stoppage of work at the Kalgoorlie mines, mentioned last month, has terminated and work has been resumed.

The shipping strike, to which reference was made last month, has had the effect of preventing the delivery of iron ore from South Australia to the Broken Hill Proprietary's blast-furnaces at Newcastle, New South Wales. The consequence is that the blast-furnaces will be closed down shortly, and afterwards the steel plant and rolling mills.

A serious fire occurred at the Sons of Gwalia on January 19, a large part of the surface plant being destroyed. The fire broke out in the gas-engine house, and it eventually damaged the milling plant and the air-compressor. The headgear, hoisting engine, slime plant, and extractor-houses were saved.

Boring for oil is to be undertaken in Gippsland, Victoria, by a company that has recently been formed called the Austral Oil Wells, No Liability. The drilling is to be done in the Morwell and Omeo districts. The occurrence of oil in this region has been observed for many years, but no exploratory work appears to have been done. The Wonthaggi and Morwell coal deposits are in this part of Victoria.

The Anglo-Persian Oil Company has made proposals to the Government of West Australia with the object of prospecting for oil in that state. The company is prepared to spend £50,000 in geological-survey work and boring. The Government appears to be disinclined to grant such large concessions as the company desires.

New Zealand.—The Waihi Gold Mining Co. announces that a proposal is to be made for the reduction of the nominal value of its shares from £1 to 10s., and the return of £250,000 to shareholders. The company has large assets in first-class securities representing about half-a-million pounds, virtually representing the nominal capital. It also has £212,500 in New Zealand bonds redeemable in ten years' time, received as purchase price for the Hora-Hora hydro-electric installation. The company has been working much poorer ore during the last few years than that which made so great a name for the mine. For some time efforts have been made to secure a new property, but so far without avail.

India.—The Burma Corporation announces that its output of refined lead during 1920 was approximately 23,816 tons and of silver 2,874,000 oz., as compared with 18,540 tons and 2,168,000 oz. respectively in 1919. Of the shipments of lead during 1920, 9,200 tons came to London and 16,312 tons went to India and the Far East. At the present time the demand for lead in the Far East is increasing so much that nearly the whole of the output is now absorbed there and hardly any is coming to London.

Cornwall.—The collapse of the tin market is having a disastrous effect on the Cornish tin mines. Our Camborne correspondent gives some account of the present sad plight of Cornwall. Every mine has closed down as far as production is concerned, and the difficulty will be to provide funds for pumping and keeping the mines in good condition. Attempts to keep Grenville going have failed and the company has gone into liquidation.

The two petitions for the compulsory winding-up of the Calloose Tin Mines & Alluvials, Ltd., have been dismissed by the Court. Mr. H. Newhouse and other shareholders, who had previously successfully petitioned for a removal of their names from the register, have had their claims against the company paid in full, so that their action was annulled. The other petition, brought by the Naraguta (Nigeria) Tin Mines, Ltd., was not pressed. The company is now free to try other properties, and the famous "Calloose" incident is at an end.

Devon.—A few months ago it was announced that Mr. H. Mallaby-Deeley, chairman of the company, had acquired the property of the China Clay Corporation at Redlake and Ivybridge, which was sold by the order of the Court. It is now announced that the amount paid was £47,000, and that a new company is to be formed with a capital of £75,000. Of this capital Mr. Mallaby-Deeley will take £47,000 in shares as purchase price, while 28,000 shares will be offered for subscription among shareholders in the old company. The old company had an issued share capital of £270,000, and there were £34,264 debentures, and it had spent nearly £200,000 on equipment. The new board is to be composed of men conversant with the china-clay business, so the actual value of the deposits should soon be ascertained.

Oil in Great Britain.—The Government Petroleum Department has issued a report on oil-drilling operations during 1920. The Hardstoft well continues to yield oil by natural overflow at the rate of 1 ton per day, and the

output for 1920 was 375 tons, of which 325 tons has been sold to the Anglo-American Oil Co. at £22. 10s. per ton. At Ironville No. 1, also in Derbyshire, there was a good showing of thick oil at a depth of 2,031 ft., at the junction of the Limestone Shales and the Carboniferous Limestone, and there were also shows in the Limestone at 2,500 ft. and 3,630 ft. At the latter point the well was shot with 180 lb. of dynamite, but with what result is not yet known on account of water in the well. At the Heath well a good show of light filtered oil was encountered at 3,940 ft. At the D'Arcy well, near Edinburgh, gas was tapped at 724 ft., with a flow of approximately 300,000 cu. ft. per twenty-four hours. At West Calder, near by, the bore gave indications of oil at several points, but the presence of volcanic rocks caused much trouble.

Canada.—The average man would never expect hydro-electric power to fail in Canada owing to shortness of water. Such, however, has been the case recently in Northern Ontario, with the result that at Porcupine and Cobalt the output of ore has been limited by the rationing of current. Our Toronto correspondent refers to this matter in his news letter published elsewhere in this issue.

United States.—The United States Geological Survey reports the output of gold in the individual states during 1920 as follows, the figures for 1919 being appended also for comparison.

	1919 $	1920 $
California	16,695,900	14,305,300
Alaska	9,036,000	7,856,000
Colorado	[illegible]	7,613,000
Arizona	4,506,400	4,493,000
South Dakota	4,862,500	4,201,400
Nevada	4,451,500	3,554,900
Utah	2,159,400	2,076,400
Montana	2,229,600	1,839,200
Oregon	980,800	965,100
Idaho	713,200	465,300
New Mexico	[illegible]	463,400
Washington	252,800	148,800
Totals	60,300,000	50,000,000

It will be seen that the decrease in production continues, and that the fall is general throughout all the States.

The Bunker Hill & Sullivan Company, of Idaho, recently built a lead smelter, and now produces its own lead instead of selling concentrates. The directors have since decided to start an electrolytic zinc plant. The Star mine contains complex ore, and this is to be treated for the production of lead and zinc concentrates, the latter to be used for zinc production. The initial capacity of the zinc plant is to be 25 tons per day, and the cost is estimated at a million dollars. It is hoped that the zinc market will have revived by the time the plant is built.

The condition of the zinc industry in the United States is reflected in the fact that work at the electrolytic plant at Anaconda has been suspended owing to the low prices ruling.

It is announced that vanadium is not now produced from Colorado ores, which consist of carnotite, the mineral yielding also uranium and radium. The whole of the vanadium used in America is now made from Peruvian ores, and it is stated that such vanadium is purer and cheaper to prepare than that made from Colorado ores.

Mexico. — Last month a brief cable was received in this country announcing the bursting of a dam at Pachuca and the consequent flooding of several mines. No confirmatory news is to hand yet. The Santa Gertrudis company announces a shortage of hydro-electric power, which will result in some contraction in the scale of operations at its various mines. Whether the shortage is caused by the accident referred to or by drought is not stated.

Bolivia.—It has already been recorded that the main reserves at the Porco tin mines have been exhausted and that the mill has been kept going chiefly on custom work. Owing to the low price of tin, it has now been decided to suspend mining and milling operations. It is felt, however, that the property should not be abandoned without some more prospecting being done in depth. A proposal is therefore being made that the shares shall be written down from £1 to 5s., and that shareholders shall be invited to subscribe a further 5s. per share. The alternative will be a foreclosure by the debenture holders, Messrs. Avelino Aramayo & Company.

Some months ago Mr. Justice Russell decided that certain dividends distributed by the Aramayo-Francke Mines, Ltd., to its German shareholders during the war should have been paid instead to the Public Custodian in this country. The company had large assets in Germany and the directors felt justified in paying dividends out of those assets to the German shareholders. An appeal from Mr. Justice Russell's judgment was before the Court of Appeal last month, and the three judges unanimously upheld the decision of the court below. It was maintained that the Custodian was the shareholder under English law. It seems hard lines that the company should not be allowed to consider the dividend as paid out of funds which had probably already been confiscated by the German Government, but the legal interpretation of the Act is presumably the correct one.

THE TRANSMISSION OF POWER BY WAVES.

By P. J. RISDON.

Particulars are given in this article of the new method of transmitting power by wave motion, invented by G. Constantinesco and developed by W. H. Dorman & Co., Ltd. Particular reference is made to the application of the system to the driving of rock-drills.

ON several occasions reference has been made in the columns of THE MINING MAGAZINE to a new rock-drill operated by means of power transmitted in waves through water. This article gives an outline of the theory of the new process, while another article to follow will give details of the construction of the various apparatus.

This important new system of transmitting power is the invention of a Roumanian, Mr. G. Constantinesco, while credit for developing it, so that it is now a practical and commercial proposition, is due to Messrs. W. H. Dorman & Co., Ltd., of Stafford. The first application of the system was in the synchronization of machine-gun fire with the revolutions of aeroplane propellers. The device enabled 2,000 shots a minute to be fired between the blades when revolving at high speed without the possibility of a single bullet striking a blade. This was known as the C.C. Interrupter Gear. The use of the principle involved has now been extended and applied so that a wave generator can transmit waves of 10 h.p. through water in a pipe 1 in. diameter.

THEORY OF WAVE TRANSMISSION.—At first sight the system might be mistaken for a form of hydraulic transmission, but in point of fact it is based upon an exactly opposite principle. In hydraulic transmission, use is made of the fact that water is only compressible to such a small extent that it serves the same purpose as a long flexible piston rod, the water being propelled bodily through a pipe and expelled from the cylinder upon completion of the stroke. In wave power transmission, the water does not move bodily forward, nor is it expelled, but remains in the system. In this case, the method depends upon the fact that water *is* slightly compressible or elastic. Assume that we have 150 metres of wrought-iron steampipe of 2·5 cm. diameter and 0·5 cm. thickness of metal, closed at one end and filled with water; and suppose a fluid-tight piston is forced into the pipe under a steady pressure of 35 kg. per sq. cm. If the liquid were incompressible the increase in volume of the containing pipe under the pressure would allow the piston to enter about 1·5 cm. If the pipe were absolutely inexpansible the pressure would compress the water to an extent that would allow the piston to enter about 26 cm. It is seen, therefore, that the compression of the water in a wrought iron steampipe of the size considered is the chief factor in the changes of volume that take place under pressure, and that the expansion of the containing pipe is almost negligible. On removing the pressure from the piston, the water will again expand to its original volume.

With other liquids similar results will be obtained. Consider what takes place in a speaking tube when the contained air is set in motion by a diaphragm, in a plane normal to the axis of the tube, that vibrates about a mean position. The first movement of the diaphragm in the direction of the tube displaces some air in the tube; this displacement is resisted by the still air farther along the tube, so that a zone of compressed air is produced in the immediate neighbourhood of the diaphragm. At the same time the moving diaphragm is giving velocity to the particles of air in its immediate neighbourhood, and these particles communicate their velocity to those beyond them, and thus any disturbance once produced by the diaphragm must travel forward along the tube. On the return movement of the diaphragm, the compressed air in its immediate neighbourhood, being elastic, expands, and we have then a zone of low-pressure air in contact with the diaphragm. The continuing vibrations of the diaphragm produce alternate zones of high and low pressure, and the disturbances so produced travel forward along the tube until the whole of the air particles in the tube are in a state of vibration; it has been found that the zones of high and low pressure travel along the tube with a definite velocity of about 1,100 ft. per second, this velocity varying slightly with the diameter of the tube. In a similar manner sound energy travels through other elastic media. The velocity through water has been found to be about 4,800 ft. per second.

As hitherto employed for the transmission of power in hydraulic systems, liquid and solid connections have been considered as movable en bloc, and for practical purposes incompressible and inextensible. Both liquid and solid columns, however, are elastic, and this property

can be made use of to transmit energy by vibrations of the particles of matter of which they are built up. We will now consider the case of liquid columns.

Assume that a pipe, instead of being closed rigidly at one end, is closed by a light floating piston held always in contact with the liquid column, but free to move with the liquid; assume further that the working piston, instead of being slowly pushed into the pipe, is connected to a rapidly rotating crank, so that it moves with a simple harmonic motion, and that, in addition to the piston impulses, a steady pressure acts on the liquid column at both ends. The only resistance to the movement of the piston is then the inertia of the liquid column, and if the column is short the liquid will move as a solid mass. If, however, the column is of considerable length the motion of the layers of liquid nearer the working piston is resisted by the inertia of the more remote layers, and on the in-stroke of the piston the liquid in its neighbourhood will be compressed and its volume diminished; it follows that the motion of the layers of liquid remote from the piston will be but very slightly less than that of layers nearer to it.

At any given speed of rotation of the crank there will be a point in the liquid column at which, on the completion of the in-stroke of the piston, no movement of the liquid has occurred. The liquid between this point and the piston will at this moment be in a state of compression, varying from a maximum at the piston to zero. At the moment of maximum velocity of the piston, the velocity of the layer of liquid in contact with it will necessarily be greater than the velocity of the more remote layers, and the kinetic energy of the layers nearer the piston will, therefore, be transmitted in the forward direction along the column. The energy expended by the piston in its forward stroke at the end of this stroke is present in the liquid column, partly in the form of potential energy due to the decreased volume of the liquid under compression and partly as kinetic energy.

On the return stroke of the piston, the compression of the layer of liquid in contact with it decreases, and expansion of the liquid takes place between the piston and the point in the column at which the pressure is a maximum. As the point of maximum pressure moves away from the piston at the commencement of the return stroke, the velocity of the layer of liquid in contact with the piston is reversed, while the pressure of this layer diminishes until the piston is at the end of its out-stroke. At the end of this out-stroke the layer of liquid in contact with the piston is for the instant at rest. As the crank continues rotating, there are thus impressed on the liquid column a series of impulses sending a series of changes of pressure and volume along the column, the particles of liquid each vibrating about a mean position.

In order that a receiver may be able to respond to the vibrations falling on it, certain conditions are essential. The part of the receiver which is to be put in action must be capable of vibrating at the periodicity of the vibrations which fall on it. Thus when it is desired to transmit power economically by means of vibrations, it is necessary that the part moved should be designed so that it can respond to the particular periodicity of vibrations at which the power is transmitted. It is further necessary, if the part moved has to perform useful work, that the work should be performed in such a manner that the ability of the receiver to vibrate in unison with the impressed vibrations is not interfered with.

Let us now consider further the case of a rapidly-rotating crank causing a piston to reciprocate at the end of a long pipe containing liquid. We have seen that a series of zones of high pressure and compression of the liquid alternating with zones of low pressure and expansion of the liquid are produced, and that these zones travel forward along the pipe.

In Fig. 1, suppose the crank A to be rotating uniformly, causing the piston B to reciprocate in the pipe C which is full of liquid. At each in-stroke of the piston a zone of high-pressure is formed, and these zones of high pressure, shown by shading, travel along the pipe away from the piston; between every pair of high-pressure zones is a zone of low pressure, shown light in the figure. The pressure at any point in the pipe, therefore, will go through a series of values from a maximum to a minimum, and these values will repeat periodically. Let the line OX represent the value of the mean pressure; then, with the piston in the position illustrated, the instantaneous pressures at different points along the pipe may be represented by the ordinates of the sine curve EFG . . K. As the rotation of the crank is uniform, it will be evident that the distances between successive points of maximum pressure will be equal. This uniform distance along the pipe at which the values of the pressure are repeated is the wave length of the vibrating movement of the liquid. If v is the velocity with which these waves travel along the pipe, and n is the number of revolutions in unit time of the crank A, it will readily be seen that the wave length y must be $\frac{v}{n}$.

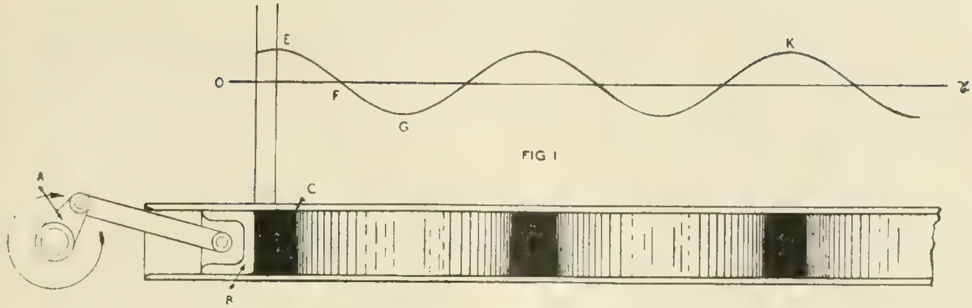


FIG 1

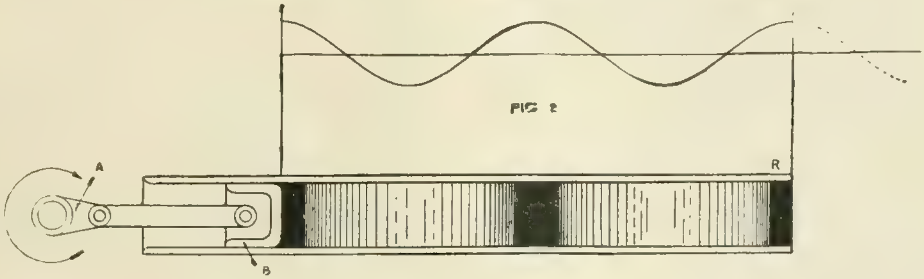


FIG 2

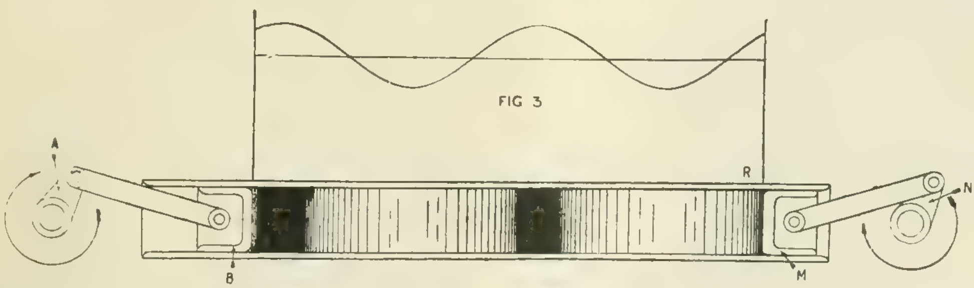


FIG 3

Assume now that the pipe is closed at the point R at a distance from the piston B equal to an exact multiple of the wave length, and suppose that the stroke of the piston is small compared with the wave length, as shown in Fig. 2. The wave of compression will be stopped at R and reflected, and the reflected wave will travel back along the pipe.

If the crank continues its rotation at uniform speed, with the length of pipe and speed of rotation we have taken, that is, with the distance from the piston B to the stop R, an exact multiple of the wave length, a zone of maximum pressure will be just starting from the piston at the instant the reflected zone of maximum pressure reaches it ; so that we shall have a wave of double the original amplitude travelling forward along the pipe. The next revolution of the crank will again add to the amplitude of the wave sent forward, and so on with successive revolutions. The result of this continual pouring in of energy is that the maximum pressure increases without limit until ultimately the pipe bursts.

It should be noted that, in a wave of greater amplitude, the maximum pressures are increased and the maximum velocities and distance of travel of the oscillating particles are also increased.

Suppose now that instead of closing the pipe rigidly at R, we have at R a piston M connected to a crank N similar to A, as shown in Fig. 3. Suppose that the crank N is rotating at the same angular velocity and in the same phase as the crank A. If the liquid column were continued beyond the piston M, it is evident that the movement of the piston would produce in this column a series of waves which would be exactly similar to and a continuation of the waves between B and M. The piston M, therefore, if moving synchronously with B, will be able to take up the whole energy of the waves produced by B and travelling along the pipe. It will be seen, further, that the piston will be able to take up and utilize the whole of the energy of the waves travelling to it if placed at any point of the pipe, provided its time period of reciprocation is the same as that

of the piston A, and provided that the phase of its movement is such as would produce a continuation beyond it of the impinging waves; that is to say, provided the piston movement is in phase with the movement of the layer of liquid in contact with it.

In the transmission of power by wave motion in this example, the maximum pressure in the pipe will at no point exceed the maximum pressure in the neighbourhood of the working piston, however long the transmission line may be; and will be the same whether the line is a single wave length or any number of wave lengths. Also the two pistons may be moving in the same or in opposite directions, and their motions may differ in phase by any angle according to the relation between the distance from one to the other and the wave length.

In the example above discussed, the whole of the energy put into the liquid column by the piston B can be taken up by the piston M. If more energy is put in by B than is taken up by the piston M, assuming no frictional losses, it is obvious that reflected waves must be formed as the direct waves fall on the piston M. The result of this will be that the surplus energy will remain in the liquid and the continuation of the rotation will continually pour in energy, increasing the maximum pressure indefinitely, until ultimately, as in the case of the closed pipe, the pipe will burst.

Suppose that, in the case of a closed pipe having a length of several wave lengths, a vessel D, completely filled with liquid, of considerable volume in proportion to the stroke volume of the piston B and with rigid walls, is placed in communication with the pipe in the neighbourhood of the piston, as shown in Fig. 4. At each in-stroke of the piston a flow will take place through the entrance to the vessel D, and the liquid in this vessel will be compressed; at each out-stroke of the piston the liquid in the vessel will again expand, and, according to the volume of the vessel, more or less liquid will flow into it and out of it at each revolution of the crank. The water in the vessel D will thus act as a spring, taking up the energy of the direct and reflected waves when the pressure is high, and giving back this energy when the pressure falls; the mean pressure in the vessel D and in the pipe will be the same, so that when the successive reflected waves in the pipe have been produced and have reached a certain amplitude equivalent to this mean pressure, the piston will merely exert energy in compressing the liquid in the vessel D on its in-stroke, and the liquid acting as a spring will restore this energy to the piston on its out-stroke. The result of this is that, when the reflected waves have been produced, there will be a series of stationary waves in the pipe, and no further increase of energy in the liquid will take place and the pressures in the pipe will never exceed the fixed limit.

By using a vessel such as D, therefore, the pipe can be completely or partially closed. It is therefore possible to place at the far end or other point of the pipe apparatus for utilizing only part of the energy of the wave, and the rotating crank A will only require to perform work to the extent of the energy actually utilized.

Consider now a case (Fig. 5) in which waves are transmitted by a reciprocating piston A along a line E-E-E provided with branches. Assume that the pipe E is closed at P at a distance of one complete wave length from the wave generator A, and that there are branches B,E,D, at the half, three-quarter, and full wave length distances respectively. We know from the cases discussed above that if the cock P is closed and the cock D open, leading to a motor L rotating at the synchronous speed, the motor L will be able to take up the whole of the energy put into the liquid by the generator.

We also know that if all the cocks are closed, stationary waves will be produced in the pipe E having maximum variations of pressure at the end P and at the half wave length B. At these points the flow will always be zero, while the pressure will alternate between maximum and minimum values determined by the closed vessel F filled with liquid. At the quarter and three quarter wave length G and C respectively the flow will alternate between maximum and minimum values, but the variation of pressure will remain zero.

In this case the points of maximum pressure and maximum movement do not travel along the pipe but are fixed in position, and theoretically no energy flows from the generator. At the points of maximum movement no variation of pressure will occur; and at the points of maximum pressure variation there will be no movement of the liquid. It is evident, therefore, that if the cock B leading directly to a motor M be opened, the motor M, running at the synchronous speed, will be able to take up all the energy given to the line. The stationary half-wave between A and B will therefore disappear, its place being taken by the forward travelling wave, while between B and P the stationary wave will persist. If the cock C leading to the motor N at the three-quarter wave length be opened, all other cocks being closed, since at the point C the variation of

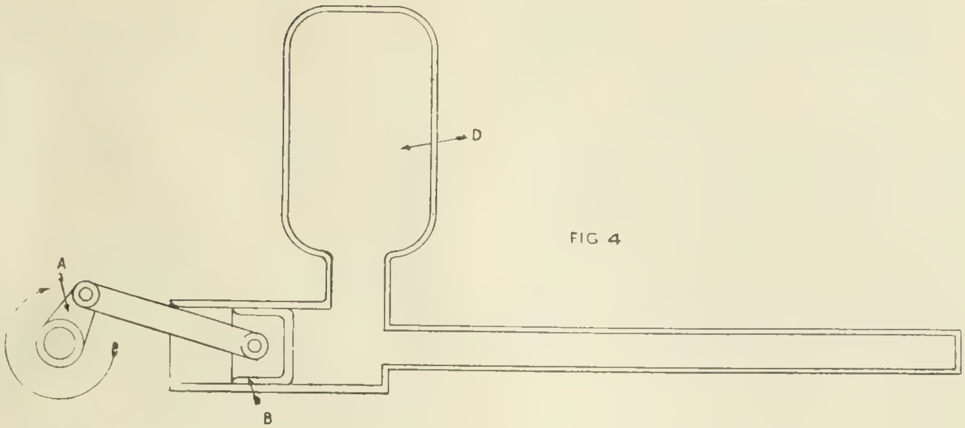


FIG 4

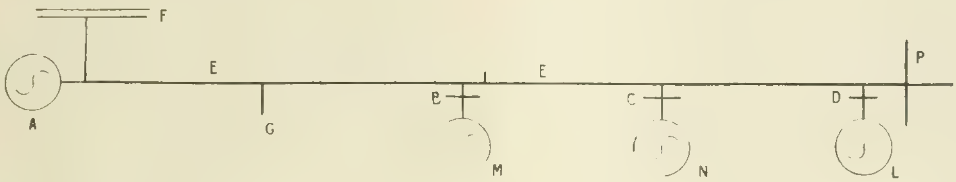


FIG 5

pressure is always zero, no energy can be taken up by the motor, and the stationary wave will persist in the whole length of the pipe.

If the motor be connected at any intermediate point, part of the energy will be taken up by the motor, while the stationary wave will persist, but will be of reduced amplitude between the generator A and the motor. The state of the liquid between the generator A and the motor may be considered as the resultant of two superposed waves; one a stationary wave, and the other a travelling wave of flowing energy.

Assume now that the motor L is not capable of taking up all the energy which can be transmitted to the line by the generator A; then we shall have superposed in the pipe a system of stationary waves and a system of waves travelling along the pipe, so that there will be no point in the pipe at which the variation of pressure will always be zero; consequently a motor connected at any point of the pipe will be able to take up and utilize a portion of the energy which is transmitted to the line.

We see, therefore, that if we have a number of motors all connected to the line, every one of them will be able to take some energy and do some useful work. It is only when no energy is being utilized that points at which the variation of pressure is permanently zero can exist.

In the next article will be given a full description of the application of the wave-transmission principle in practice, with particulars of the wave-generator, means of transmission, and method of applying the power to rock-drills and other tools.

(To be concluded).

Sir John Cass Technical Institute.—The annual distribution of prizes was held on February 10, the ceremony being performed by Sir Frederick Black, president of the Institution of Petroleum Technologists. Sir Frederick subsequently delivered an address on "Liquid Fuel in Peace and War."

Robert Peele, author of "Compressed Air Plant" and "The Mining Engineers' Handbook," is the subject of an appreciative notice in the *Engineering and Mining Journal* for January 15. Mr. Peele graduated at the Columbia School of Mines, New York, in 1883, and for several years thereafter was engaged in mining and metallurgical work in Colorado, Arizona, and New Mexico. Afterwards he went to Colombia and Dutch Guiana, and subsequently, from 1890 to 1892, he was in Peru and Bolivia for the Peruvian Corporation. In the latter year he became assistant professor of mining in the Columbia School of Mines, but retained his professional business, being a member of the firm of Olcott, Corning, & Peele. In 1910 he visited the Rand and the diamond mines at Kimberley.

THE PHYSICAL BASES OF TIN-DRESSING.

By R. T. HANCOCK, Assoc.Inst.M.M.

INTRODUCTION.—To-day the wet method of dressing by which tin ores are concentrated is little more than an interesting survival. All other ores of importance (wolfram is not important at present) are, or can be, successfully treated by smelting, chemical, or flotation processes. And the Cornish industry is looking forward hopefully to the day when one of these will be made applicable to its own problems, and is altogether indisposed to countenance investigation into the methods it already practices. With a personal belief that this day is more distant than those whose thoughts are fathered by their wishes are inclined to believe, I have collected the following notes, and hope that something will be found among them of service to those who are now engaged in guiding the industry through a particularly critical period.

Anyone who is engaged in dressing ores should have a clear idea what his object really is. The mere percentage recovery of the metal content means nothing; this can best be secured by avoiding dressing altogether. Metallurgically, the efficiency of the result of an ore-dressing operation is expressed by the difference between the percentage recovery of the original metal or mineral content and the percentage "recovery," or retention in the concentrate, of the waste matter or gangue present in the original ore. Economically, efficiency is reckoned in the same way, but here the retention in the concentrate of a given percentage of the original waste generally more than counterbalances the recovery of a similar percentage of metal or mineral, and so the percentage retention of the waste must be multiplied by a factor depending for magnitude on the prevailing economic conditions before deducting it from the percentage recovery of metal or mineral in order to correctly express the economic efficiency. In this paper metallurgical efficiency will alone be considered.

ACTION OF A FLOWING STREAM ON SOLID PARTICLES.—The late Dr. Grove K. Gilbert, in "Transportation of Debris by Running Water" (Professional Paper No. 86 of the United States Geological Survey), distinguished two main sets of conditions of transport:

(1) Over a smooth surface. (Flume traction).

(2) Over a bed of the deposited solids. (Stream traction).

The first condition is found on the rag frame and on the Frue vanner, and the second on the buddle.

A transitional stage may be recognized where the load is a little too great for complete transport over a smooth surface, so that part settles out and the condition changes to transport over a deposited bed. The capacity of water to transport solids is much the greater over a smooth surface, though decreasingly so as the particles are smaller, and if part of the load deposits it will build up the bed till a steeper grade is established. From the point of view of capacity of machines, a consistency of pulp such that deposit does not take place would appear preferable. A tendency to deposit is responsible for the formation of patches of settled material which may lead to channelling if flow is continued. Initially these patches are due to rhythm in the flow of the water. In stream traction they are represented by dunes, and with this mode of traction the formation of dunes was found to be at a minimum on slopes of approximately 1% grade, the region being little affected by changes in other conditions. No similar observation on flume traction is recorded.

The sizes of sand used by Gilbert ranged from 60 mesh to coarse gravel, and the quantities of water from 0·141 to 1·119 cu. ft. per second per foot of width. The smaller of these quantities is equivalent to 528 lb. of water per foot of width per minute, which is enormously in excess of anything used in ore-dressing. On the other hand the slopes seldom exceeded 2%. For the treatment of slimes on fixed slime tables, Professor R. H. Richards proposes 2 lb. of water per minute per foot of width, and Professor S. J. Truscott, reproducing on an experimental frame the conditions prevailing in Cornish practice, used practically this same quantity. Nevertheless, it would appear legitimate to apply some of Gilbert's conclusions to the study of slime treatment.

In Gilbert's experiments on stream traction, the sized sand was caused to flow over a bed formed by the deposit of that sand itself. Resistance to transport—indicated by low capacity of the flowing water for sand—appears to be at a maximum when the bed thus corresponds in roughness to the size of the moving particles. Over a bed composed of smaller grains, larger particles move more rapidly. The same thing applies with any degree of roughness of sur-

face however arising. Yet experiments conducted at the Utah School of Mines, and recorded in *Mines and Minerals* for February, 1909, showed a larger capacity for 10 to 30 mesh limestone tailings and 30 to 40 mesh pyrites in launders lined with linoleum or of wood than when the launders were bottomed with plate-glass. Large quantities of water were used (from 10 to 60 lb. per inch of width per minute), and the observation is probably connected with the fact that at velocities exceeding about 1 ft. per second, the velocities of the flow of water in a wooden pipe (planed) is much greater than in a glass pipe of the same diameter and on the same gradient. Thus with pipes 4 ft. in diameter and lying on a 1% slope the velocity in the wooden pipe would be 15 ft. per second against 11 ft. per second in the glass pipes. The laws of flow change below the critical velocity of about 1 ft. per second, and it is not known if the same is true at lesser velocities. The subject of the inherent properties of surfaces of different bodies, which manifest themselves as above and in other ways, is of special interest to the investigator, but can be no more than referred to here.

In Gilbert's experiments on stream traction (deposited bed), the capacity of the water as a carrier of debris increased regularly as the debris was finer. With flume traction (smooth bed), on the other hand, there might be sizes too large to roll at all, but for the next smaller capacity was high and decreased as size of particle decreased until a minimum was reached corresponding to a critical size varying with the flow conditions, after which further decrease in particle size was attended by a steady increase in capacity. (See Fig. 1). It is a matter of common observation that in a sluice bottomed with sand, coarse particles travel down faster than the sand grains over which they roll, and that the larger outstrip the smaller. On the other hand, particles small enough to remain in suspension travel as rapidly as the water itself.

The travel of particles over a bed or surface is mainly by rolling for the largest sizes and suspension for the very smallest, these two systems grading into each other through a type of motion called by Gilbert "saltation," in which the particles both roll and leap, the latter predominatingly as the particles are smaller. Saltation is the motion of the majority of the particles.

The mathematical treatment of the behaviour of particles which roll is discussed by Professor Henry Louis in "The Dressing of Minerals," and elaborated by St. Rainer in the issues of *Oesterreichische Zeitschrift für Berg- und Hüttenwesen* of February 4 and 11, 1905.

As the velocity of a current decreases with depth (a generalization, but perhaps true of all currents carrying loads), any particle in suspension is subjected to a force which causes it to move into a slower-moving stratum, and consequently to sink. The greater the rate of change of velocity with depth, the greater this force. Tea-leaves seek the centre of the cup on stirring, and not the outer margin where centrifugal force would naturally place them. Thus a suspended particle will sink to the

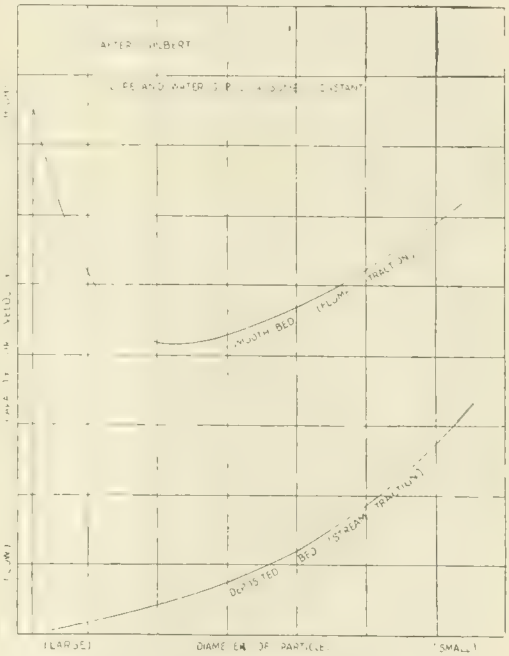


FIG. 1.

bottom more rapidly than it would if acted upon by gravity alone.

CONCENTRATION CONDITIONED BY MINIMUM VELOCITY.—Only a limited number of experiments were conducted by Gilbert on flume traction, and, under the particular conditions employed, minimum capacity or velocity was found associated with a coarse sand. Evidently the minimum will occur where the particles are too small to respond freely to the couple which produces rolling, and yet too large to pass freely into suspension. Stream conditions favouring suspension will cause the size of sand characterized by minimum velocity to be large. With any stream conditions there must be a particular size of particle which will travel slower in that stream than any larger or smaller particle of similar shape. As to

what this size may be there is little available evidence.

The late J. J. Beringer (Transactions Institution of Mining and Metallurgy, Vol. xxiv, p. 411) gives the following estimate of the sizes of particles in concentrates based on microscopic examination:

Slime product	from 5 to 45 μ	Average 25 μ
Vanner product	,, 25 ,, 95 μ	,, 50 μ

one micron (μ) = 0·001 mm.

In the same contribution (The Physical Condition of Cassiterite in Cornish Mill Products) he mentioned a case where vanner tailings from the calcined concentrate were returned to the vanner for treatment. "The second concentrate on being examined under the microscope showed distinctly two different sizes, a coarser portion with grains measuring from 50 to 75 μ, and a finer portion with grains measuring from 10 to 15 μ, a fair proportion being of 10 μ size."

I regard this as strong evidence that the first treatment abstracted particles of a size ranging about a definite mean magnitude, say 40 μ, and the second treatment saved particles on the margins of this range which had escaped under the first treatment more or less by accident. There are those who believe that the vanner treatment of unclassified pulp saves fine slime tin which would not be caught otherwise. The above figures might be claimed to support such a theory, but it is in the highest degree unlikely that such fine particles would form a distinct group with practical absence of particles ranging from their size to those constituting the remainder of the concentrate. It may be added that Mr. H. W. Hutchin has sought for evidence of such extra saving, and failed to find it.

I am strongly of opinion that with any given set of conditions the sizes of the particles of mineral in the concentrate produced will be grouped about a definite mean magnitude, and the mineral in the tailing will be predominantly composed of particles of a size on one side or the other (or both) of this range. The concentrate particles, both mineral and waste, will be those which travel most slowly under the actual flow conditions.

Where there is a marked difference in the specific gravities of mineral and gangue, as with tin ores, the tendency to roll and the reluctance to pass into suspension will extend further into the region of small sizes with the cassiterite than with the gangue, and consequently the gangue found in a concentrate would consist of larger particles than the accompanying cassiterite. A grading analysis of such concentrate would show the values mainly in the finer sizes. But as in an elutriation analysis the finest material is unavoidably reported as of lower grade than the actual sorting by screens would show, this feature is not usually conspicuous in published instances of grading analyses so made. Moreover, such concentrates as have been examined in this manner have usually been produced in an endeavour to obtain a low-grade tailing rather than effectively concentrate, and so do not show the full effect of the above-noted tendency. Further, the grading analysis of a concentrate or tailing is profoundly modified by the treatment history of the product from which it is originally derived. Consequently there are no data in existence which indicate what particular sizes of crushed quartz (say) travel slowest under given conditions of slope and water-supply. A particular size might still remain associated with minimum velocity if slope were changed and water-supply suitably modified.

Mr. J. A. Davis (*Engineering and Mining Journal*, November 9, 1908) gives the formula which follows for the best dressing conditions in separating closely-classified galena from quartz on a glass frame, as determined in the laboratories of the Massachusetts Institute of Technology:

$$\text{Slope in inches per ft.} \quad \frac{1}{8}\left(\frac{275-50\sqrt{\frac{1}{d}}}{W}+\frac{10}{\sqrt{\frac{1}{d}}}\right)$$

where d = average diameter of quartz particle in millimetres, and W = lb. water per foot of width per minute.

It was found that the classification had been carried a good deal further than was necessary for good results, and that a large number of classified products from an original pulp were not necessary. No determinations were made on sizes smaller than about 180 mesh, and the formula is so empiric as to make its extension to slimes very unreliable. But it is of interest to observe that with 300 mesh material two lb. of water per foot of width per minute would call for a slope of 2⅛ in. per foot.

With a feed in which the values are regularly distributed throughout the range of sizes, variations in flow conditions, within such as are practicable for dressing, would have little effect on the efficiency of concentration resulting. The actual particles of mineral (say cassiterite) saved under one set of conditions might be quite different from those saved under another, and the gangue particles which accompanied them different individuals in either case, but the resulting proportion of mineral to gangue is not necessarily modified. Perhaps as a consequence of this it is not easy,

in the many cases instanced by Truscott in his paper on "Slime Treatment on Cornish Frames," to say definitely that a given set of conditions of flow produces better results than another. When there is a difference it can usually be as well ascribed to other causes. Truscott in fact decides that the finer the material the less the inclination should be, while Richards comes to the exactly opposite conclusion as the result of his own experiments, but admits that he does not find any rule to be followed in practice. Where, on the other hand, the distribution of the values is irregular in the feed, or a classified product is being treated, a particular set of conditions will doubtless give better results than any other, but such conditions must be found by trial.

In any ordinary ore-pulp, and under any set of conditions in reason, there will always be certain particles of gangue which will behave exactly as do certain particles of valuable mineral, and will accompany them either into the concentrate or the tailing. Even if it were possible to break up this grouping by specially adjusting conditions, it would only mean the substitution of one group for another with little effect on the final result.

Although it has been implied that the particles forming the concentrate will be those having the slowest travelling rate under the prevailing conditions, it must be borne in mind that the dominant size of the particles in the concentrate is a function, not only of the travelling rate, but of the distribution of the various sizes through the original pulp. Thus if there is a group adjoining the slowest travelling group, which forms a comparatively large percentage of the pulp, that group is likely to predominate in the concentrate. A usual practice is to re-treat tailings under different conditions of slope. A shift of the range of size of saveable cassiterite may now be expected, and sizes saved which previously escaped, but it is evident that an adjacent group of barren material will now be present which was rejected in the first treatment, and this is likely to be thrown into the second concentrate by the very changes which made that collection possible. Consequently the re-treatment of tailings in this way is not a very satisfactory process. To repeat the original treatment on a tailing product serves its most useful purpose when the original treatment was not carried to completion. Thus in the case instanced by Beringer, the first vanner concentrate was produced at an efficiency of 62·5% with a recovery of 78%, while the concentrate produced by re-treatment of its tailing was at an efficiency of 3·3% with a further recovery of 5·5%.

It becomes evident that effective concentration is much more dependent on the initial physical condition of the feed than on any adjustment of dressing conditions.

Granting that the effective concentration of ores by the flow of water over smooth surfaces in thin films is dependent for success on the fact that under these conditions certain particles travel more slowly than others, then it necessarily follows that on a frame fed at a regular rate and with a normal feed there will result an accumulation of such particles on the surface, such accumulation not resulting from their actual arrest or settlement, but simply from their slower motion. As the feed period is prolonged these particles continue to progress down the frame, and after a certain time reach its lower edge and commence to pass into the tailing. During the feed period the assay of the escaping tailing increases, not necessarily regularly, for that depends on the physical condition of the feed, and at the moment when the first fed of the slowest travelling particles passes the lower edge, the assay of the tailing increment then escaping attains the assay of the feed. Naturally it can never exceed it, but will remain at the same figure if feed is further prolonged. During the time that each increment of tailing passing the lower edge has a lower assay than the feed, the efficiency of concentration is increasing and attains its maximum at the moment when the former attains the assay of the feed, decreasing if feed is further prolonged. Given regular feeding and flow it follows that the assay of any strip taken at right angles to the flow when maximum efficiency is attained will be the same as that of any other strip. The enrichment thus attained will be the maximum under the conditions employed, and if there is one set of conditions better suited to the ore than another, a determination of the enrichments attained will give a pretty good guide to its selection. The actual efficiency attainable cannot be ascertained unless the feed is interrupted at the critical moment, to discover which it will be necessary to sample successive tailing increments.

The best length of feed period will vary directly with the length of the frame, and with any given pulp and dressing conditions there is a particular feed period best suited to a given length, and vice versa. The condition of an even assay all down the frame is one that is attained from the feed-end downwards, and when half the correct period has elapsed, the upper half of the frame should assay the same all over, the area extending as feed is prolonged

until the whole frame is so covered. Terminal conditions, especially at the feed end where the feed may come on to the frame with an acquired velocity different from that generally prevailing on the surface, are left out of present consideration. When the lowest part of the frame is thus covered, the assay of the material escaping just below is nevertheless not higher than that of the original feed. In other words, the assay of the material flowing across a particular narrow strip is an altogether different thing from the assay of the material on that strip considered as suddenly arrested there. This is not an altogether easy thing to realize. The ratio of the "arrested" assay to the "flowing" assay may be quite high, and is a measure of the tractability of the ore. It may be that this ratio is preserved on the lower part of the frame before the feed period is completed, but this point is of little more than speculative interest.

In the experiments which were carried out at Great Falls, Montana, described in the Transactions of the American Institute of Mining Engineers for 1913, with the object of devising the best means of saving copper slimes, the conditions finally adopted were such that the assay of the concentrate collected on the round tables was the same from top to bottom, with the exception of a strip at the feed-end. It is interesting to note that this research led to the installation of a system of slime treatment at Anaconda which paid for the erection of the necessary plant in two months, and thereafter saved $1,250,000 per annum.

PROFESSOR TRUSCOTT'S RESEARCHES.—In the paper already referred to, a number of experiments are described where the distribution of the concentrate down the frame was determined by dividing it into five sections at right angles to the flow, and assaying and weighing the concentrate on each section. Employing the data obtained, if the reciprocals of the cumulative enrichment ratios be plotted against the cumulative percentage concentrations, it is found that the loci corresponding to the lower sections fall closely along a straight line. The first section, sometimes the first two, and in one case the first three, do not conform to this arrangement. I find strong confirmation of the views I have expressed above in these facts. The lower sections are those below the limit of maximum enrichment, and the graphs confirm my view that if feed were prolonged there would be no sections conforming to the law indicated by this straight line, but that the plotted points corresponding to all the sections would lie along a line parallel to the percentage concentration axis. Fig. 2 shows the plot of two such experiments on a wooden surface with auxiliary washing, all the plots, whether on wood surfaces, plate or fluted glass, and with or without washing, being of the same general character. All the experiments having been conducted with the same length of feed-period, no direct evidence of the effect of a longer feed-period is available, but an increase in the slope would have a similar effect, and it will be observed that this is to shorten the length of the line representing the lower sections, the inference being that with a

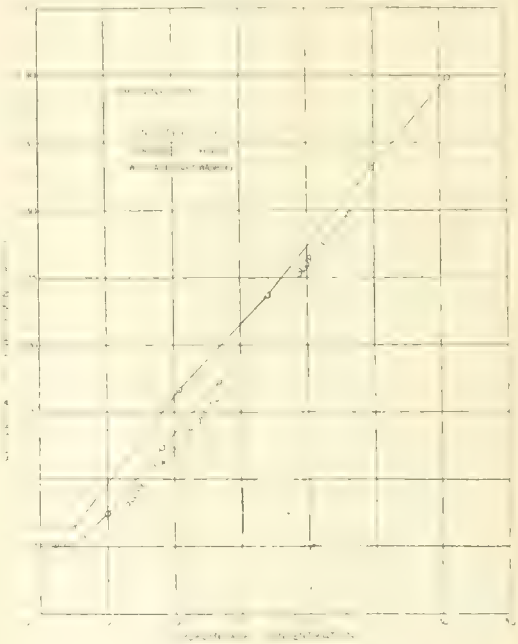


FIG. 2.

sufficiently long period of feed, or one duly proportioned to the gradient and the length of the frame, this sloping line would disappear altogether, leaving only the short horizontal portion of the graph. If feed were unduly prolonged, this horizontal line itself would shorten. Two different laws, then, are desirable from a study of the graphs, the first and most conspicuous being that on the lower sectons of a frame on which concentration has not been pushed to maximum efficiency, the relation of enrichment ratio (ER) to concentration (C), both cumulative, is expressed by a formula of the type

$$\frac{1}{ER} = a + bC$$

the second being that on those sections where maximum efficiency has been attained the

cumulative enrichment is equal to a constant.

This last law, which is demanded by the theory of concentration outlined above, is not very strongly supported by the different graphs, possibly because in the majority of cases concentration has not been pushed anything like far enough to show its application clearly, but in the one case observed where concentration has proceeded furthest, it may fairly be said that the first three sections out of the five conform to the required law. Further support is derived from the Anaconda researches already mentioned.

The first law, the law of the lower sections, may be written :

$$R = \frac{C}{a+bC}$$

which is the equation of a hyperbola. A straight line equation can also be derived connecting cumulative percentage recovery (R) with cumulative enrichment ratio.

A law, or mathematical formula, expressing the relation of recovery to concentration has long been sought, and its discovery here is therefore of some interest, but of very little practical importance, as it merely serves to express the relation existing on a frame where flow has been arrested, and arrested too soon. What is of real importance is the assay of the flowing pulp, and not that of the arrested pulp.

The data indicate that under the conditions and with the particular conditions of flow given, a shorter frame would have given better technical results, and on these grounds Truscott suggests that the present length of the Cornish frame should be diminished by half in order to secure the improved efficiency characteristic of the upper sections. But actually no guide to the appropriate length can be found in the figures obtained, as these relate only to the arrested concentrate, and give no clue to what might have been the assay of the flowing pulp at the different points. It is where the flowing pulp has the same assay as the feed that determines the optimum length of frame, and not the assay of the arrested concentrate on any particular section. With the feed conditions given, the data, if obtainable, would point to an even more drastic shortening of the standard frame than Truscott proposes.

In a supplementary paper Truscott describes experiments carried out at Dolcoath where the ordinary 6 ft. 6 in. frame was run against a frame divided into two lengths of 3 ft. each with arrangements for collecting the upper and lower concentrates separately. These experiments were carried out under ordinary mill conditions and are therefore of special interest. It was considered that the results demonstrated the general superiority of the 3 ft. frame, but I do not altogether concur after a detailed examination of the figures.

Frame length.	Tests.	Slope per ft.	Feed period.	% Recovery.	% Concentration.	Enrichment.	% Efficiency.
6 ft. 6 in.	6	1·25 in.	2·7 min.	71·2	63·9	1·113	7.2
Do	2	1·50 in	4·4 min.	61·7	40 3	1·535	21·4
Do	1	1 50 in	5 0 min.		—	—	24·1
3 ft.	8	1 50 in.	5·6 min.	4 30	1·50	2·87	28·0

Increased steepness of gradient, as it causes a general speeding-up of all the particles, is similar in effect to a longer period of feed.

The above figures seem to indicate that with equal feed periods and slopes the technical results would have been equal on both types of frames, and further that a longer period of feed than was employed in any case would have given better results still.

Truscott claims that the adoption of his suggestion to cut down the length of the frames would enable an effect styled "rapid enrichment" to be attained, better technical results being obtainable on half the present area of frames employed, the remaining area becoming available for re-treatment of the tailings from rapid enrichment. This is undoubtedly true, but as far as better technical results are concerned, it seems probable that these could equally be secured on the present frames by increasing the length of the feed period. It is difficult to see any justification for the present practice of gradual enrichment, though one usually exists for empirical methods which have been evolved in Cornwall through the experience of centuries, and I am inclined to regard such practices with considerable respect, but since it is comparatively yesterday that accurate methods of ascertaining the true contents of an ore or tailing were evolved, it is perhaps permissible to review them in a fresh light. A frame is a machine, and it is difficult to justify the employment of a machine at far below its maximum efficiency.

Two sets of experiments were conducted by Truscott on a laboratory scale to ascertain whether the customary practice of obtaining the final concentrate in three stages possessed any marked advantage over his suggested method of obtaining it at one operation. The first of these was tried on slime samples from Dolcoath and South Crofty. The similarity of the results was remarkable, the efficiency of the final result of gradual enrichment being 31·3%, of rapid enrichment 30·6%, and of rapid enrichment at a double rate of feed 28·7%.

In the second set original mine-ore was ground to the condition of slime. Again the

results showed great similarity, the average of the four ores giving an efficiency of 65·4% with gradual enrichment, 65·8% with rapid enrichment, and 64·3% with rapid enrichment at a double rate of feed. Calculating the figures for the individual ores, Tresavean ore gave an efficiency of 64·3% with all three methods, so it is evident that no importance is to be attached to such slight differences as were shown, but that these were only such as might easily arise in experimental determinations.

Further experiments were conducted on the tailings resulting from rapid enrichment and from rapid enrichment at a double rate of feed, but not on the tailings from gradual enrichment. A further recovery was effected at low efficiency rates, and a claim was based on the figures for increased recovery in the form of saleable concentrate as a result of the adoption of the principle of rapid enrichment, but it is evident, if the weights and assays of the three tailings are calculated and compared, that their composition and physical state could not have varied very much whichever of the three processes was adopted, and a similar further recovery might have resulted from the re-treatment of the combined tailings from gradual enrichment, so that rapid enrichment does not necessarily render possible a higher recovery of saleable concentrate than if the present system of gradual enrichment were employed. Any advantage of rapid enrichment lies in the more efficient employment of the dressing surfaces, lowering the dressing cost, and so making it possible to chase values further.

A method of calculating the final recovery in the form of saleable concentrate was used in the paper, based on the result of a single stage of treatment, and it purported to show that the reduction of the mine-ore to slime in the first instance and its treatment on frames in the manner described might produce better results than coarser crushing and the preliminary classification of the pulp into sands, fine sands, and slimes, for individual treatment. If the basis of this calculation be examined, which is that the loss suffered by a medium-grade concentrate in being raised to merchantable grade varies inversely with its assay, it is found to be the same as stating that the tailing removed at every subsequent stage of dressing will assay the same as the original battery feed, a most unlikely series of events.

Returning to a consideration of the Dolcoath experiments, a striking feature is that, contrary to what might be expected, the tailing assays were actually lower with longer periods of feed. Thus on the standard frame with 1·25 in. slope and a feed period of 2·7 min. the tailing assay was 6·4 lb., with 1·5 in. slope and 4·4 min. feed it was 6·45 lb., and on the double frame (combining both concentrates to get the equivalent length to a standard frame) with a 1·5 in. slope and 5·6 min. feed it was 5 lb. These figures require to be corrected for differences in the average assays of the respective feeds, and allowing for these, the figures are in the ratios 0·80 : 0·64 : 0·60. The probable explanation is that the first tailings to escape are rich slimes, which naturally continue to escape during the whole operation, but their effect becomes masked by the later arrival of poor sands. If these sands are retained on the frame through short duration of the feed period, the whole operation suffers in efficiency.

In frame treatment a pulp having the values mainly associated with a certain range of size of particles will require for best results altogether different dressing conditions from those best suited to a pulp having the values mainly associated with a different range of sizes. Any pulp may be considered as consisting of a mixture of two or more such pulps, all being treated together under conditions which are more or less a compromise. It is useful to regard certain pulps from this point of view, particularly those consisting of tailings where the operation producing them has taken a big bite out of a certain range of sizes and left the principal values in the tailings on either side of this range, such as the vanner tailings instanced by Beringer, the conditions in this respect recorded by him being probably true of vanner tailings in general. An attempt to adjust the dressing conditions to save the faster travelling particles of cassiterite means that scarcely any effective concentration of the slower travelling fraction is obtained, yet this seems to be what is generally done. The escaping tailing increment, mainly slime, quickly attains the assay of this rapidly moving portion of the pulp, and this may be high. If feed is now stopped, the concentrate arrested on the lower portion of the frame may well be of lower assay than the whole of the tailing which has escaped, as Truscott found with an experiment on Dolcoath No. 4, a typical specimen of this class of pulp. Further experiments were conducted on this pulp to determine whether a longer period of feed might give better results; as the experiments were designed to reproduce on a flat frame the conditions obtainable on a round table by slowing down its period of revolution, a washing period was given, and this was longer with longer duration of feed. An unfortunate arithmetical error was responsible for the de-

cision that the shorter period was best, but the following observation is a better record of the facts: "The appearances suggest that owing to the relatively high inclination much of the very fine tin goes direct to the tailing, but that if discard were continued the next material to go would be poor sand."

Truscott's experiments on whole pulps, that is, on pulps which represent the whole battery product, such as those on his synthetic ore and on the mill-ores ground to the condition of slime, indicate that the maximum enrichment obtainable on frames without washing will be about 14·3 associated with a concentration to 5%, a recovery of 71·6%, and consequently an efficiency of 66·6%. Any attempt to push enrichment further by washing seems to be at the expense of efficiency. These figures, and in particular the efficiency, are dependent on the physical condition of the ore, and not on its original assay. They demand that the cassiterite should have been practically freed from its matrix. The richer the original ore, the richer will be the concentrate and tailing in direct proportion. With a 1% ore, the concentrate would assay 320 lb. per ton, and the tailing 6·7 lb.

Instances of the frame treatment of thickened overflow from classifiers taking the original mill-pulp are not sufficiently numerous for close figuring, but indicate, in the case of the Tincroft slime, an efficiency of possibly 50%, with a 4 lb. tailing, the latter low figure being due to original feed only assaying about a half per cent. This on what might be described as a classified feed.

SHAKING TABLES.—Such figures as are available relating to the performances of tables of the Wilfley type and Frue vanners, in the treatment of unclassified or original pulp, do not indicate that a higher efficiency is attainable by these machines than on flat frames. Messrs. Cox, Porter, and Gibbon ("Mineral Industry," 1911) obtained figures which I believe relate to the performances of a Wilfley on copper ore, though my notes are not complete in this respect, which show that the efficiency with which the natural ore was treated was 64·4%, the mean efficiency of treating this ore in separate lots graded by screening being 63·9%, and of grading the lots by classification 66·7%. In obtaining these averages it is assumed that each of the six lots obtained by each grading process were of equal weight. The minus 100-mesh lot obtained by screening was treated at an efficiency of 48·7%, the average of the remainder being 67·3%, while the finest product of classification was treated at an efficiency of 51·2%, the average of the remainder being 69·8%. An advantage of shaking-tables lies in their greater capacity per unit of floor area. Thus the Frue vanner will handle one ton per foot of width in 24 hours, a flat frame requiring six feet of width to treat this tonnage. The effect of shortening the frame length, increasing the gradient, and feeding a larger quantity of a thicker pulp than usual, all of which appear feasible, would be to place the two appliances on a more equal footing as regards area capacity.

WASHING.—The general question of washing remains to be discussed. Washing is not practised on flat frames, and the complications which its employment would entail militate against its adoption unless a very marked advantage can be demonstrated. Where concentration on a flat frame has not been carried to the point of maximum efficiency, washing is somewhat similar in effect to a prolongation of the feed period, and is therefore commonly attended by improved technical results. Washing will in fact improve the technical result just so long as the tailing increments escaping during the washing period do not attain the assay of the feed. Where the feed period has been so prolonged that maximum technical efficiency has been obtained it is difficult to see that washing can further increase this, and certainly it has not been demonstrated. Nor has it been demonstrated that a higher efficiency is attainable by auxiliary washing than by the selection of a suitable period of feed.

Round frames, on the other hand, are always provided with arrangements for washing. The concentrate from these goes customarily direct to the calciner, and the function of washing is here to increase the enrichment, even if a slight loss in metallurgical efficiency is thereby incurred. If it is attempted, by employing the principle of rapid enrichment in the flat-frame treatment of slimes, to obtain at one operation a concentrate sufficiently high-grade to send to the calciner, some means of washing might be advantageously employed in the same way.

CLASSIFICATION.—The term classification is reserved to express sizing by the employment of rising hydraulic currents and covers a rather wide range of effects, from the mere division of a mill-feed into sands and slimes, to the operation of a multiple-spigot classifier of the latest type.

Cornish practice has come in for a good deal of outside and not always too well-informed criticism on account of the small part which classification supposedly plays in it, particularly that classification direct from the stamp

which some, who have not sufficiently taken into account the nature of the subsequent processes, consider essential to good work.

Granted that the concentrate produced by a frame, vanner, or other smooth surface, consists essentially of finer cassiterite associated with coarser waste, its becomes evident that classification, by throwing together fine cassiterite and coarse waste, is the deliberate preparation of the worst possible kind of material for treatment on a smooth surface. This arises from the existence of a minimum value on Gilbert's curve of velocities plotted against particle diameters treated under flume (smooth surface) conditions. A coarse particle of quartz may occupy a position on the descending leg of the curve which will indicate the same velocity as possessed by a small particle of cassiterite on the rising leg. It is possible, of course, that if the classified product consisted only of two such groups, one of quartz and the other of cassiterite, a modification of the flow conditions might be made which would place the cassiterite in the minimum velocity position, but hardly anything is known of the modifying effect of such changes, except in the vaguest way, and extreme niceties of adjustment cannot be secured and preserved in practice. The more perfect the classification, the more likely it is to be attended by ill results, and the practice of treating the whole battery pulp on vanners without classification is abundantly justified. It is possible that the dilution of the slime feed consequent to classification also has an injurious effect. Mr. J. Bland (*Engineering and Mining Journal*, June 28, 1919) has published figures showing that on a Deister No. 3 slime table the concentrate contained 40·2% of minus 1/2,000 in. wolfram when the consistency of the pulp was two and a half parts by weight of water to one of solids, whereas none of this fine wolfram was recovered when the consistency was twelve to one. The quality of the concentrate did not suffer, but the capacity of the table was reduced as thicker pulps were treated, and the percentage recovery and extent of concentration are not stated.

RECOVERIES BY TIN STREAMERS.—As the amount of concentrate recovered in a saleable condition forms so small a portion of the whole mill-feed, the total tailings produced by the various operations of the mill, if put together finally, would reproduce very closely in physical condition the original feed as it came from the stamps, allowance being made for supplementary crushing undergone by some fractions. The intractability characteristic of the tailings of a particular machine would be found to have largely disappeared if such a combined tailing were put through a mill again, and the preliminary stage of its treatment might be attended with something approaching the high degree of metallurgical efficiency characteristic of an original pulp, due allowance being made for the fact that a much larger fraction of the cassiterite in the pulp would not be free, but combined as chats. The foregoing seems a quite sufficient explanation of the fact that streamers make satisfactory recoveries of tin which has resisted saving in the original mills. It is not in the least necessary to drag in "colloids" or imagine that the cassiterite undergoes some physico-chemical change in its passage down the Red River.

The intractable condition of a tailing can also be modified by re-crushing before re-treatment, which smoothes down the asperities of the grading analysis, and reproduces a pulp of a more normal type. This alteration of the grading analysis is an advantage additional to the liberation of previously attached cassiterite, and as re-grinding is obviously limited to coarse products, is an argument in favour of preliminary coarse crushing.

THE BUDDLE.—So far the conditions discussed have been those prevailing on a smooth concentrating surface. Those which obtain on a buddle are quite different, for the reason that the flow conditions are now more those of the stream (deposited bed) traction of Gilbert. Yet here also the influence of a minimum value in the velocity curve has not altogether disappeared, but persists for a reason which has been left undiscussed: that over a surface which is not perfectly smooth, the maximum retarding effect on a moving particle is found on a surface whose roughness corresponds in grain to the size of the particle. The behaviour of the particle is of course not conditioned by this cause alone, but this is the principal one. The roughness of the surface on the buddle increases toward the discharge periphery, and every particle finds an appropriate resting-place among its fellows. There is nothing in the theory that cassiterite tends to catch cassiterite; size is most important in deciding where any individual comes to rest, and the influence of specific gravity seems to be secondary. Some tests made by me on Nigerian concentrate obtained by a process akin to buddling showed that the finer grained fraction separable by screening was of noticeably lower grade than the coarser, the specific gravity of the waste mineral being 4·7 to 5, proving that a slight diminution in size caused particles of lighter material to hang back among the denser cassiterite.

It is much to be regretted that no data are in existence on the performance of buddles comparable to those obtained by Truscott for frames; but I am inclined to think that such data would establish that the buddling of mixed (unclassified) sizes causes the cassiterite to persist through the buddle products in a way that might be prevented by feeding the buddle with a classified pulp.

The operation of panning is in many ways comparable to buddling in that the coarser particles tend to roll across the mass deposited in the bottom of the pan and escape, the resulting concentrate being one of finer grain as well as of denser material. So that certain figures published by Professor Edwin Edser in a recent communication to the Institution of Mining and Metallurgy may be usefully studied, although they were given solely with a view to the elucidation of a law of concentration connecting recovery with enrichment. The material tested was a sample from a Cornish river deposit containing waste cassiterite from tin-dressing operations. This waste was screened through 80-mesh and the undersize elutriated into seven products by the method described by Mr. Thomas Crook in the appendix to Hatch and Rastall's "Petrology of the Sedimentary Rocks." This method would doubtless give products obtained under free-settling conditions, and not so perfectly graded as those obtainable with a classifier working under hindered-settling conditions, yet, as a laboratory product, perhaps more perfectly classified than would result from the operation of a hindered-settling classifier on a practical scale.

The two finest sizes proved unsuitable for panning (but not for framing), and the remaining five, 77·6% of the total, were panned individually to an average concentration of 15% sampled and assayed, and further panned down to an average concentration of 1·3 per cent.

First stage of concentration:

Mesh	Weight	Recovery	Concentration	Efficiency	Tailings lb.
A −2,500	13·2				
B −1,800+2,500	9·2				
C −1,000+1,800	12·6	0·808	0·129	0·679	4·0
D − 570+1,000	7·7	0·840	0·162	0·678	2·7
E − 300+ 570	8·7	0·748	0·216	0·532	4·0
F − 200+ 300	36·2	0·684	0·125	0·559	5·1
G − 80+ 200	12·4	0·777	0·215	0·562	3·6
Totals and averages	100·0	0·745	0·154	0·591	4·3

Thus from an original feed assaying 14·4 lb. Sn per ton, a recovery of 74·5% has been effected in a concentrate assaying 70 lb. per ton, with a concentration to 15·4% of the original weight, the tailings assaying 4·3 lb.

The second concentration of the concentrates obtained above gave the following results, reckoning from the original feed:

	Recovery	Concentration	Efficiency	Tailings lb.
C	0·656	0·014	0·642	5·1
D	0·660	0·014	0·645	4·0
E	0·590	0·020	0·570	5·2
F	0·437	0·008	0·429	8·1
G	0·585	0·018	0·567	5·3
Totals and averages	0·563	0·013	0·550	6·4

Thus the combined result of the two stages of concentration was to produce a concentrate assaying 605 lb. per ton, with a recovery of 56·3% of the original contents in a concentration to 1·3%, with a combined final tailing assaying 6·4 lb. per ton.

The combined tailings made in producing the second concentration from the first assayed 21 lb. per ton, showing that the concentration was pushed too far in the second stage for the best metallurgical result. This was particularly the case with product F, the second tailing of which ran 31 lb. per ton.

It is my opinion that if buddles were fed with a well-classified feed from a multiple-spigot hindered-settling classifier, something closely approaching the foregoing results could be duplicated in practice. Such a result, for instance, on a 1% ore, as 1·5 tons of 500 lb. Sn concentrate ready for the calciner, 13·5 tons of 85 lb. middling for re-treatment, and 85 tons of 4 lb. tailing for final rejection. The existence of this comparatively large tonnage of middlings would be due to unavoidable imperfections in classification and to the existence of chats, the latter particularly in the coarser sizes. Such coarser middlings might be re-ground and returned to the classifier circuit, while the finer middlings went back to the same classifier to get another chance. If the loss in dressing the first concentrate and middlings up to shipping grade amounted to 11 lb. per ton, the final mill tailings would run 5 lb. per ton.

Present practice may perhaps be guessed at as producing a final tailing at 8·3 lb. per ton from 1% ore, composed as to two-thirds of sands at 5 lb. per ton, and as to one-third of slimes at 15 lb. per ton. A reduction to 5 lb. per ton on the whole tailing would mean an additional saving of 3·3 lb. per ton, equivalent to an increased recovery of 14·3% of the contents of the original feed, or an increase of 20% in the amount of saleable concentrate now produced.

At the prices which prevailed in April last, this would mean an additional annual income to the industry of £200,000.

I realize that this is an extremely bold claim to put forward as the result of a single series of laboratory experiments, and prefer to sub-

mit the figures which the experiments actually support without allowances for contingencies which can be supplied by the reader. It is apparent that it is quite possible to recover a high percentage of the slime-tin content of a pulp in a concentrated form if suitable means of dressing are provided. There is nothing disclosed showing that successful slime treatment is impossible through anything arising from the nature of slime tin itself, indeed the finest slimes panned gave the highest efficiences, and that there were two still finer products made by classification but not tested in this way does not imply that these would have to be run to waste, as Edser only rejected these as difficult to perform a second treatment on to establish a particular mathematical treatment, and states that they yielded a concentrate to framing.

Still greater improvements might be expected in the recoveries of arsenic and wolfram, as the present losses of these are mainly in the slimes.

It may be objected that a proposal to substitute buddling on a wholesale scale for the present semi-automatic handling of the pulp would lead to an increase in milling costs. A study of present slime plants will, however, show that many operations, although cheaply performed, are of such low efficiency that while each stage costs but little, the multitude of stages is responsible for a high total cost. The proposed system would have the effect of reducing the tonnage sent to the calciner and tin-yard, where the bulk of the manual handling takes place at present, and of rapidly reducing the tonnage handled at each stage.

Milling ore in which the tin is not exceptionally fine, and where a single-spigot is now employed in front of the stamps to feed tables of the Wilfley type, the overflow going to the slime plant, the battery pulp might be sent direct to the tables if these have sufficient capacity. These would be set to produce a sandy tailing for rejection going about 4 lb. per ton, after the slimes in it had been removed by a Bunker Hill screen or in some similar way. The oversize of this screen, which might amount to 30 or 40% of the whole mill-feed, would be rejected without further handling. A comparatively small table-concentrate would go direct to the calciner, and a large middling product would pass to a tube-mill running in circuit with a single-spigot classifier, the table-slimes joining the circuit at any convenient point. The whole product, suitably thickened, would pass to a multiple spigot hindered-settling classifier making eight or ten products, the spigot products going to separate buddles and the overflow to frames. It will be objected that there is no classifier now on the market designed to classify slimes in the manner required, classification not being practised at present below 200 mesh. It would not be possible to employ an existing type by modifying the velocity of the rising current, as the areas of the quicksand and sorting columns have to be relatively proportioned with regard to the size of the material with which they deal, and the problem would appear to be no more than one of design. The heads of the buddles would go to the calciner, the tailings to waste, while the middlings from the buddles treating the sandier products would be sent back to the tube-mill, returning via the multiple-spigot classifier, to which the middlings from the buddles treating the finer products would also be returned without further reduction. There would appear to be no good reason for calcining the different products apart, except perhaps as regards the original Wilfley product, and the whole calciner product would be passed through a similar multiple-spigot classifier and the products buddled. The heads would be tossed and buddled until fit for market, and the whole of the tails might require re-pulverizing, so that no part could be returned direct to the calciner-classifier for re-sorting.

In milling ores where the tin occurs in a fine state of division the probable procedure would be to pass the whole of the battery pulp, crushed through a fine grate, over Frue vanners without classification, pulling a high-grade concentrate for the calciner, and sending the whole of the tailings to the multiple-spigot classifier. The products sent to the buddles then being usually of lower grade than those handled in the previously considered case, a larger fraction of the buddle contents would be rejected as waste, and only a small proportion of the middles, if any, would be re-ground. Thereafter treatment would follow the lines already indicated.

CONCLUSIONS.—*Frames:* The sizes of particles saved on a smooth surface, as of a frame or vanner, are grouped about a definite mean magnitude and the tailings are characterized by intractability to re-treatment.

In the treatment of unclassified pulp, variations in dressing conditions within practicable limits do not greatly affect the technical result, except that a thicker pulp may possibly effect an increased saving of finer particles.

Washing is of value only as an expedient, and does not produce technical results otherwise unobtainable from the view-point of metal-

lurgical efficiency. Under appropriate circumstances, improved economic results may be obtained by its employment. The duration of the feed is the most important factor in deciding the technical result of a single operation on a frame. With a given ore, appropriate duration will vary directly as frame length, and there is no reason to anticipate better technical results on a short frame than on one of customary length. The customary duration of feed is too short to secure the best technical result of a single operation.

The technical result obtained by selection of the optimum length of feed period can also be secured by stage treatment in which the duration of feed in each stage is shorter. The combined tailings obtained by the latter method do not differ in character from those yielded by the other, and no better technical result finally is indicated apart from the simplification and cheapening of dressing which the other gives.

Classification of feed intended for treatment on frames or vanners is likely to produce inferior results. That better results can be obtained by classification coupled to the selection of appropriate dressing conditions remains to be established by research.

Buddles: Buddles should receive a classified feed. The close classification into a number of grades of the material now sent to the slimes plant, and its treatment by buddling, promises an improvement over present recoveries amounting to possibly 20%.

ON THE ESTIMATION OF MINERAL RESERVES.

With special reference to the Iron Ores of Cumberland and Lancashire.

By J. D. KENDALL.

ON pp. 45-48 of vol. viii. Iron Ores (Geological Survey) there are a number of statements on this subject so misleading and so utterly at variance with the recent practice of mining engineers that I am at a loss to understand why they have been allowed to appear in that publication.

Nineteen years ago, I invited the attention of the members of the Institution of Mining and Metallurgy to the very elastic use of the phrase "Ore in Sight." In many cases then it simply meant ore in imagination, which, I need hardly say, has not any marketable value, unless it be to the unscrupulous promoter. A long adjourned discussion followed the reading of the paper and, on my invitation, a committee was formed to consider the matter. As a result of the deliberations of that committee the

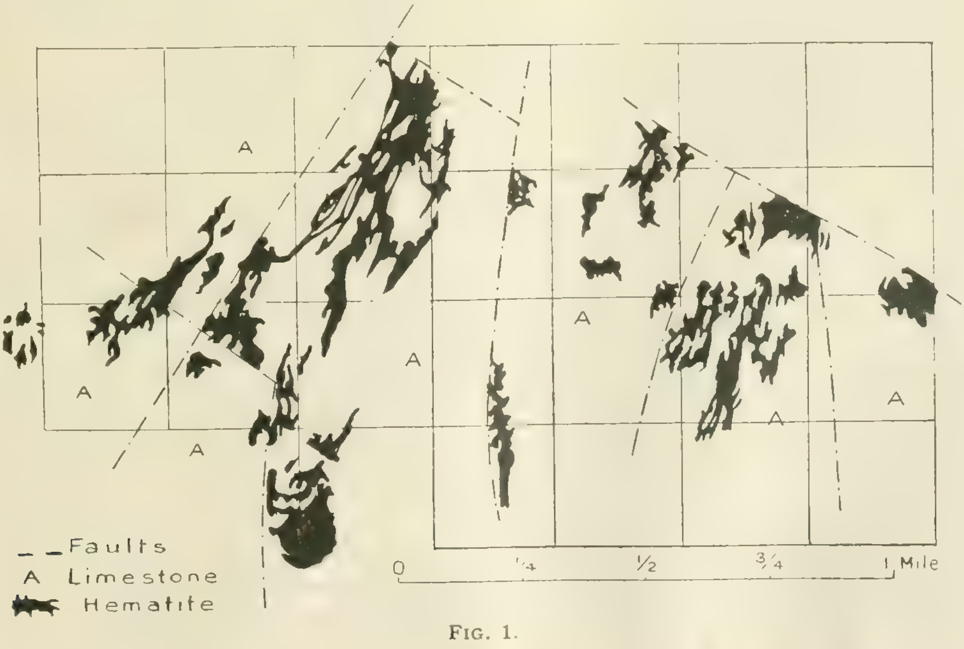


FIG. 1.

Institution sent out to its members a number of recommendations of which the three following are the essence:

(1) That members of the Institution should not make use of the term "Ore in Sight" in their reports without indicating, in the most explicit manner, the data upon which the estimate is based; and that it is most desirable that estimates should be illustrated by drawings.

(2) That as the term "Ore in Sight" is frequently used to indicate two separate factors in an estimate, namely: (*a*) ore blocked out, that is, ore exposed on at least three sides within reasonable distance of each other, and (*b*) ore which may be reasonably assumed to exist though not actually blocked out. These two factors should in all cases be kept distinct, as (*a*) is governed by fixed rules, while (*b*) is dependent upon individual judgment and local experience.

(3) That in making use of the term "Ore in Sight" an engineer should demonstrate that the ore so denominated is capable of being profitably extracted under the working conditions obtaining in the district.

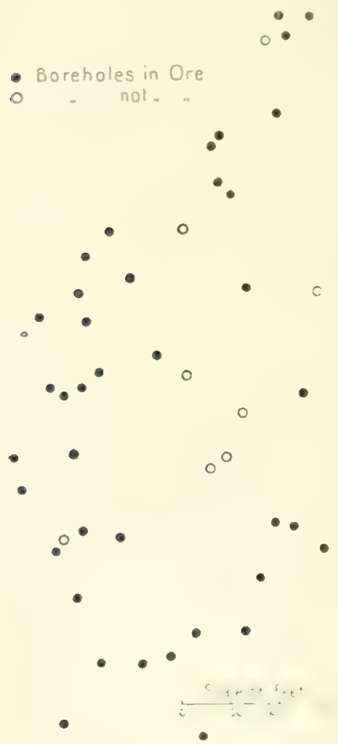


Fig. 2.

Since these recommendations were issued I have not seen anything so glaringly bad in the way of estimates as the passages from the Memoir above referred to, which I will now quote.

Referring to the possibility of finding further ore between Lamplugh and Egremont, the Memoir says on p. 45: "Assuming, in the absence of definite information, that ore is present in average quantity, we allow a reserve of 8 million to 10 million tons, some of which, however, may be difficult to win." In reference to the area south of Egremont we read on p. 47: "Provided that ore occurs as freely in this area as in the proved field to the north, there should be a reserve of about 50 million tons of ore, apart from that already allowed for in the Ullcoats-Winscales district." On the same page, a little lower, we read: "On the assumption that the ore occurs between the Hodbarrow Mines and the Park and Ronhead group as freely as in Furness generally, we estimate for this tract a reserve of some 24 million tons of ore, about equally divided between Cumberland and Lancashire." On p. 48 the following summary of reserves is given:

Fig. 3.

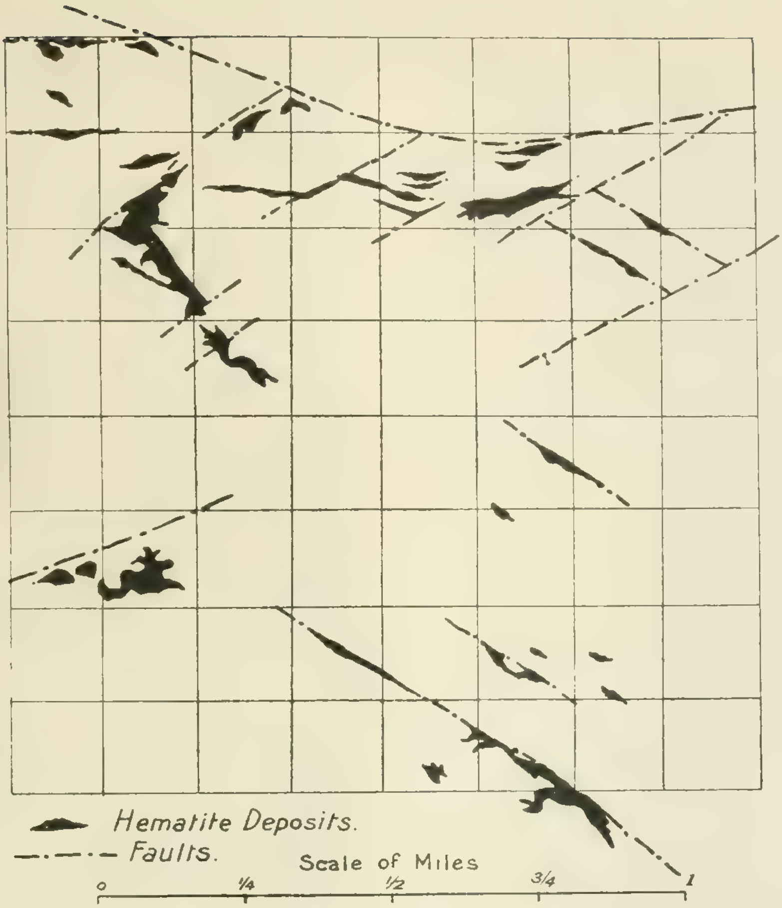


FIG 4.

		In Million Tons Proved	Unproved
Cumberland	Lamplugh-Egremont		10
	Egremont-Yotten Fews	40	50
	Millom District		12
Lancashire	West of Dalton		12
	East of Dalton	5	6
		45	90

The Memoir does not employ the phrase "Ore in Sight," but the word "Reserves." These are shown by the above table to be divided into two classes, "proved" and "unproved." Nothing is said as to how the proof, in the case of the former class, was effected, but in the sequel I will endeavour to show that it is impossible to estimate quantities in these ore-bodies with any approach to accuracy unless the ground has been blocked out.

Unproved reserves are reserves in anticipation and imagination only. That there is still a large quantity of ore to work beyond that blocked out in each of the three fields may be confidently expected. But how much no one can say, nor what proportion of it can be worked at a profit. The 90 millions of the Memoir is no more likely to be even the approximate total than 20 millions or 200 millions. There is as much justification for any one of these quantities as for either of the others. There is really no justification for fixing any quantity.

If 90 millions is not an aggregate of unadulterated guesses, it must have been reached by involving assumed quantities per unit area into unknown, because unexplored, areas. Such a product, it will be readily admitted, cannot be of the least value either commercially or scientifically.

Fig. 1 represents a part of the Whitehaven mining district, showing some of the most important deposits hitherto worked. They occur on different geological horizons, some in the First and Second Limestones, some in the Third and Fourth, others in the Seventh. It will be seen that there is no fixed relation between land areas and the areas of deposits in that land. Each of the squares in Fig. 1 has an area of about 41 acres. Some contain a

large proportion of ore, some very little. But that fact is still more evident when the area shown in Fig. 1 is looked at in conjunction with other parts of the district, where the spaces between the deposits are much larger.

Fig. 2 shows the positions of 49 bore-holes put down in a rich part of the district. Forty of these holes proved ore on the same geological horizon. Nine were in limestone. Twenty-five years ago I suppose most mining men who had not given serious thought to the vagaries of hematite deposits would have said that these holes—their positions and journals only being known—proved the existence of an ore-body interrupted by but a comparatively small extent of limestone. Let us see what was the fact.

Fig. 3 shows the plan of the ore-bodies, proved by the 49 bore-holes, after the deposits had been practically exhausted by the miner. It also gives the relative positions of all the bores shown on Fig. 2.

There were 4·44 times as many bores in ore as in limestone, but the area of the limestone, splitting up and enclosing the ore within the area covered by the holes, was 2·78 times larger than that of the hematite. To reconcile the results obtained in some of the bores with those of the miner it must be remembered that bore-holes are seldom if ever quite plumb and sometimes they are a long way from being so.

This is not a specially selected case to illustrate the erratic nature of these ore-bodies, as will be seen by reference to Fig. 1. There have been deposits in which the ore was less interfered with by limestone, but that could not be known until they were laid open, that is, until they were blocked out.

Fig. 4 is a plan of some of the more important deposits in Furness. It is on the same scale as Fig. 1, but many of the deposits shown on it have a vein-like habit, and therefore do not make so great a display horizontally as those in Fig. 1, nearly all of which have a bed-like form. Each square has an area of about 15·9 acres. All the deposits of importance that have been found in the area covered by Fig. 4 are shown on that drawing, but only a few of the larger faults. It will be seen that, as in the Whitehaven district, there is not any fixed ratio between the area of ore-bodies and that of the limestone in which they occur. Here, too, as at Whitehaven, it is impossible to estimate reserves that are not blocked out, and for the same reason.

If Fig. 4 be compared with Plate III. of the Survey Memoir, a fair idea may be obtained of the neglect of this district by the Geological Survey. Only two faults are shown on that plate in the area corresponding to Fig. 4, and neither of them exists in the ground, while the ore-bodies do not bear any resemblance to actuality.

A map of mere rock-areas is of very little value to the explorer. He wants to know the structure of the probable ore-bearing ground.

If it is not possible to form anything like an accurate estimate of the quantity of hematite that may exist in a deposit that has been pierced by 40 bore-holes, as shown by Figs. 2 and 3, what value can be placed on estimates in which—like those of the 90 millions of the Memoir—there is an entire absence of evidence?

LETTERS TO THE EDITOR

Genesis of Cumberland Iron Ores.

The Editor:

Sir—Mr. J. D. Kendall discusses the origin of the iron ores of Cumberland and Furness in a paper entitled "The bearing of the distribution of certain metallic minerals on their genesis," which appeared in the MAGAZINE for November, 1920.

He makes three points to which I desire to refer:

(*1*) Some of the veins of hematite occur in the Skiddaw slates, the Borrowdale rocks, the Ennerdale granophyre, and the Eskdale granite, in situations which he attempts to show were never overlain by Triassic rocks. The iron ore in these veins could not, therefore, he contends, be derived from the iron oxide of the Trias.

(*2*) The Permian breccia directly overlying a deposit of hematite in the Carboniferous Limestone near Orebank House, Bigrigg, in the Cleator district of Cumberland, contained angular fragments of hematite evidently derived from the deposit on which the breccia lay, and which deposit, therefore, must have been in existence before the breccia was formed.

(*3*) He contends that the view that the hematite deposits were formed by the downward filtration of iron ore from overlying Triassic rocks, "if held by those having the direction of explorations, would lead to a great waste of time and money."

As regards (*1*) I do not think we have sufficient data—we may never have—to decide how far the Triassic rocks extended over the Lake District. In the jumble of geological events so many things may have happened that it is safer not to dogmatize. As Mr. Kendall indicates, the late Mr. J. G. Goodchild thought that the Carboniferous and later rocks spread

at one time over the entire Lake District.

The northern part of the Isle of Man resembles in many of its features the Lake District. We have at the Point of Ayre the Saliferous Marls, then, going south, the Triassic and Permian, then the lower Carboniferous, and finally the Manx slate rocks rising to a height of 2,034 ft. at Snaefell.

Mr. Lamplugh, in his Geological Memoir of the Isle of Man, remarks on p. 1 : " The predominant feature of its stratigraphy is the central ridge of slate and greywacke, which seems to have constituted an insulated tract at as early a date as the beginning of the Carboniferous period. This prototype of the present island appears afterwards to have been enfolded and obliterated by the sediments of later times; but with the progress of denudation the old ridge has once more emerged from beneath this mantle." And on page 25 : " Before the commencement of the Carboniferous period, erosive influences had cut deeply into this old massif, the rocks of which at that time already possessed the lithological and structural characters that we find in them to-day. By this early denudation there seems to have been shaped out an isolated hilly tract approximately resembling the present land, which was probably afterwards buried under sediments of Carboniferous and later times, and thus during long ages protected from erosion. By the stripping away of these enfolding strata, probably finally accomplished during Tertiary times, the central position of the ridge was once more exposed, and must since have lost considerably in altitude."

Mr. Kendall's arguments in favour of a central tract in the Lake District that was never overlain by later rocks do not impress me. They seem to me to be mere speculations.

The certainties appear to be as follows: The Lake District is now more or less surrounded by belts of Carboniferous, Permian, and Triassic rocks. These beds formerly extended nearer the centre, covering a larger area of the Lake District than they cover now. The central mountains were pushed up. What area of the Lake District was once covered by Carboniferous and later rocks is speculative, and depends on another speculative matter, the dates of the various upheavals and sinkings of the mountains.

If I were to venture on a conjecture it would be something in this form. I would grant Mr. Kendall his island at the close of the Yoredale period, and this would account for " the occurrence of a rounded boulder of Ennerdale syenite (granophyre) in the shale between the Sixth and Seventh Limestones, at Crossfield mines." I would suppose the Lake District to be sinking and the Coal Measures to extend partly over it. With later sinking after the Coal Measures were laid down, rocks of Permian, Triassic, and possibly later date would be formed, creeping nearer and nearer the centre of the area and possibly entirely covering it. The Triassic rocks might then directly overlie " the Skiddaw slates, the Borrowdale rocks, the Ennerdale granophyre, the Eskdale granite," and furnish the iron contents of the hematite veins occurring in them. Then upheavals and denudation left the rocks as we now find them.

With respect to (*2*), if Mr. Kendall's account is correct it is a strong argument in favour of the genesis of the Cumberland hematite deposits before the formation of the Permian breccia. It is to be regretted that the particular evidence he describes is completely destroyed, and also that at the time it was available the fragments of hematite found in the breccia were not submitted to microscopical examination so as to attempt to determine if they were replacements of limestone fragments in the breccia by the same ferruginous solutions which Goodchild and others contend formed the irregular masses in the solid limestone below, and were not in fact fragments of hematite torn from a pre-existing deposit of hematite.

If the masses of hematite in the limestone were formed by descending ferruginous solutions, it would be surprising if these solutions on their way through the breccia did not attack and replace some of the limestone fragments in it. I am advised by geologists that an examination of such fragments might indicate whether they were replacements or fragments derived from a pre-existing mass. It is rather singular that such an examination has not been made, and I think the Geological Survey people have been remiss in not making the investigation.

I have endeavoured for some time to obtain specimens of hematite from the breccia so as to submit them for examination, but so far I have not been successful. It is not necessary that the specimens should come from breccia directly overlying a deposit of hematite. If it was found that the pebbles and fragments of hematite in the breccia were replacements of limestone fragments *in situ*, it would weaken Mr. Kendall's views as to the date of the deposits in the body of the limestones. It would not, however, prove the downward filtration theory, as it could still be urged that ascending

solutions or vapours had affected both limestone and overlying breccia.

Great light would be thrown both upon the genesis and the age of hematite deposits by a microscopical examination of the pebbles and fragments of hematite found in the Permian breccia, and to this matter I would strongly direct the attention of geologists.

The proximity of Triassic rocks to the Carboniferous Limestone cannot be urged as a reason for not expecting hematite as (*3*) would seem to imply. Even if, as Mr. Kendall thinks, the iron oxide from the Trias played no part in the formation of hematite deposits in the underlying limestone, yet he cannot deny that, in the hematite districts of Cumberland and Furness as well as in North and South Wales, the Forest of Dean, and Derbyshire, Triassic rocks are in close proximity and can with some certainty be said to have overlain at one time the areas where the deposits occur. Indeed, in the southern part of the Cleator district of Cumberland, and in parts of the hematite district of South Wales, hematite is or has been worked in the limestone now overlain by Trias.

I fail, therefore, to see how it can be argued that even if the Trias has no relation to hematite deposits in the limestone any loss of time or money in exploration can result from the opposite view.

J. B. ATKINSON.

86, St. George's Terrace,
Newcastle-on-Tyne, December 14.

The Editor:

Sir—In the last paragraph of Mr. J. D. Kendall's interesting article in THE MINING MAGAZINE of November last, he alludes to the chemistry relative to the deposition of the North-West of England hematite deposits. It is a well-known fact that gypsum is comparatively abundant in the Triassic strata. Is it not reasonable to infer that the gypsum is very likely the residual salt resulting from the replacement of the Carboniferous Limestone by hematite through the agency of powerful solutions of ferric sulphate from below? That reaction is conveniently represented by the following equation:

$$3CaCO_3 + Fe_2(SO_4)_3 = 3CaSO_4 + Fe_2O_3 + 3CO_2.$$

If this reaction can be taken as probable, then we have still further evidence of mineralization from below. Whereas, on the contrary, no striking abundance of gypsum is found below the Carboniferous Limestone. It would be interesting to know whether, in the opinion of Mr. Kendall, the amount of gypsum in the Triassic strata could represent a residuum from the reaction that I suggest.

A. ALEC JONES, Assoc.Inst.M.M.

Millom, Cumberland, January 8.

The Editor:

Sir—I thank you for letting me see Mr. Jones's and Mr. Atkinson's letters so that my replies may appear in the same issue.

In his letter, Mr. J. B. Atkinson has, I assume inadvertently, omitted the evidence on which he bases the numerous statements made. If he will be good enough to supply this most important deficit his readers will, I think, be able to form a more reliable judgment. If, for instance, we take paragraph 11, in which Mr. Atkinson first puts forth his ideas, we find the following statements: "If I were to venture on a conjecture it would be something in this form . . . : I would suppose the Lake District to be sinking and the Coal Measures to extend partly over it. With later sinking after the Coal Measures were laid down, rocks of Permian, Triassic, and possibly later date would be formed, creeping nearer and nearer the centre of the area and possibly entirely covering it. The Triassic rocks might then directly overlie the Skiddaw Slates, etc." Here we have a number of suppositions but no evidence.

The next paragraph seems to indicate that Mr. Atkinson is not sure of my presentation of the facts relating to the occurrence of ore fragments in the Breccia near Orebank House. But he does not say why. I invite him to do so. As I have previously told Mr. Atkinson, I sliced hematite fragments from the Breccia, for microscopic examination, 40 years ago, but found no difference between them and pieces taken from the mine. In both, the sections varied considerably, some containing numerous minute quartz-filled cavities. In others there was nothing but iron ore. Mr. Atkinson says, "Great light would be thrown both upon the genesis and age of hematite deposits by a microscopical examination of the pebbles and fragments of hematite found in the Permian Breccia." One would naturally expect, after, or before, a positive statement like this, some evidence would be adduced, for Mr. Atkinson says *would*, not *might*.

To the last paragraph of the letter I need not add to what I have said elsewhere, beyond this: "Hematite is or has been worked in the limestone now overlain by" boulder clay (Mr. Atkinson says Trias), but that is not any reason for thinking there is some intimate relation between them. It is merely an incident in geological evolution. The same statement may

be made with reference to the Trias.

In reply to Mr. Jones's letter, there are two reasons why the suggested reaction cannot, in my opinion, be accepted as an explanation of the facts. (1) The volume of calcium carbonate required as precipitant is so much in excess of the volume of hematite precipitated that the cavities formed in the limestone would be very much larger than the ore-body. (2) The ore and the gypsum referred to were not formed at or near the same time.

J. D. KENDALL.

London, January 28.

The Finsbury Technical College.

The Editor:

Sir—In an article published under the above heading in THE MINING MAGAZINE for November, reference was made to the threatened extinction of the Finsbury Technical College, and a powerful appeal was put forward for the continuance of this historic school of engineering and industrial chemistry. One emendation may, however, with advantage be made in this otherwise excellent notice, in regard to two references to the Board of Education as the authority which contemplates closing the College. On the contrary, although the Board has never had official relations with the College, yet it has on at least two recent occasions expressed warm sympathy with the movement set on foot by the Finsbury Technical College Defence Committee. Hitherto the Board of Education has not been called upon to contribute towards the financial support of the College, this responsibility having been undertaken solely by the City & Guilds of London Institute for the Advancement of Technical Education. The Board has, however, intimated that if the future of the College could be assured it would be prepared to offer material assistance.

In a statement issued by the City & Guilds of London Institute last July a survey is made of the circumstances in which the Institute is constrained to terminate the educational work of the College in July, 1921. With much of this explanatory statement those interested in the scientific and technical education of the Metropolis will have the fullest sympathy. It is evident that the Institute is averse from entering into competition, on very unequal terms, with institutions liberally subsidized by the Local Education Authority, which in the present instance is the London County Council. The Defence Committee has, however, found strong support for the view that there is still abundant scope for the continued existence of the pioneer technical college of the London area. The great traditions of instruction and research associated with the memory of such illustrious teachers as Ayrton, Perry, Meldola, and Silvanus Thompson, and the undiminished success of the College under their successors, constitute a priceless asset worthy to be conserved and utilized in the training of future generations of students of applied science. With the spread of the Finsbury Defence Movement it is becoming more widely realized that it is precisely this side of the Institute's activities for which there is at present the greatest need. In regard to the recent past, the imperial importance of the Institute's work in the College may be gauged by the war services rendered by the staff and former students of Finsbury. "Happy is the man that hath his quiver full of them, for he shall not be ashamed when they speak with the enemy in the gate."

G. T. MORGAN.

London, December 29.

NEWS LETTERS.

MELBOURNE.

December 9.

WELFARE SCHEMES AT MOUNT LYELL.—During the past three or four years the Mount Lyell company, like many other big industrial concerns in the Commonwealth, has been carrying out a welfare scheme for its mining employees, the bulk of whom reside at Gormanston, near the mines, the principal feature being the provision of comfortable and adequate housing accommodation. This problem, in an isolated district like Mount Lyell, is naturally a difficult and expensive one to overcome, but the company is striving earnestly and determinedly to cope with it, and the results are highly gratifying. There has just been finished a block of ten houses, which makes a total of 38 erected since the initiation of the scheme. The dwellings contain four or five living rooms, and are built of hardwood, lined throughout with either similar wood or 3-ply material. They are of simple and neat design, and have been built under the supervision of Mr. R. M. Murray, engineer-in-charge of the mines, and his staff. Malthoid and shingles are used for roofing, and, in addition to the four or five living rooms, each dwelling is furnished with pantry, scullery, washhouse (in some instances a bathroom), woodshed, and sanitary accommodation. The land is sufficient to provide reasonable yard and garden space, which is all securely fenced. Electric lighting, heating, and power are sup-

plied direct by the company at the reasonable rate of 4d. per unit for lighting and 2d. for power, and the water supply is provided by the municipal council. The building of these houses is, however, not by any means the limit of the company's efforts in this direction, as, in addition to the 38 houses built, they have purchased from time to time other dwellings, many of which were in a dilapidated state, and made them fit to live in. Altogether the company owns in Gormanston about 100 houses for the benefit of their mine employees. The rent charged for the dwellings is only 7s. 6d. per week for a four-roomed and 9s. for a five-roomed cottage, and it is fairly safe to say that in no industrial centre or large city of the Commonwealth can as good houses be found for ordinary workers of all classes as those which the Mount Lyell company is providing for its mine employees at such low rentals.

Another detail of the scheme is the promotion of direct trading, by what are virtually co-operative establishments. The company, for about 18 months past, has been the only supplier of meat in the Gormanston centre, having purchased the businesses of those local butchers who complained that they could not carry on owing to the high price of stock. Under the company's management the meat supply business has been reorganized on lines which mean a reduction of 2d. and 3d. a pound as compared with the prices charged by private firms. In furtherance of their scheme, the company, a few months ago, also acquired the principal general stores in the municipality, and are now supplying groceries and general food commodities, household ironware, crockery, etc., and in the clothing line all classes of working requirements, including blueys, oilers, and boots. With a view to encouraging the cash system of trading, and eliminating, as far as possible, the credit system, the company offers every inducement to the people to pay cash and thus get their goods at the lowest possible prices. All purchasers of meat who pay cash at the shop are allowed 1d. per lb. as against that sold on the fortnightly credit basis, while at the general store the buyer paying cash is allowed 10% discount, and there is no doubt that a very large number of the consumers are taking advantage of the benefits of this cash system.

Another item in the welfare scheme is the providing of facilities for improving social life, and to this end the company has established and equipped recreation halls at both Gormanston and Linda, where for 6d. a week comfortably furnished billiard, reading, and pastime rooms are available to the employees and the public generally, and this in itself is a great help towards minimizing the unfavourable climatic and living conditions which are inseparable from a rough and isolated district like the Mount Lyell mining field.

It must be understood that, although the company is financing the business and taking the responsibility of monetary loss, it is not out to make any profit whatever in its trading department. The business is purely co-operative, with practically no expense or risk to the employees (and employees in this connection means the whole of the Gormanston community, every member of which, if not directly, is certainly indirectly, employed by the company), the principle aimed at being the supply of goods at cost price, after allowing for the cost of purchase, management, and distribution, thereby eliminating the retailer's profits. As the turnover in the butchering and general store business is approximately £60,000 a year, it will easily be realized what an appreciable benefit this trading department is to the employees and the public of Gormanston generally. The men as a body are not at all backward in acknowledging the efforts of the company to establish sympathetic relations with their employees. If the result of the Mount Lyell Co.'s action in this direction is to eliminate strikes or other industrial troubles, and prevent stoppages of work, the money will have been well spent.

ELECTROLYTIC ZINC IN TASMANIA.—The works near Hobart of the Electrolytic Zinc Co. of Australasia, which were started in 1917, now employ some 1,200 workmen, and rapid constructional work is being carried on. A representative of the *Industrial Australian and Mining Standard* has made a tour of inspection in company with the general manager, Mr. H. W. Gepp. In addition to the buildings, wharves are being constructed along the banks of the Derwent 1,000 ft. in length and 60 ft. wide, with a depth of 30 ft. at low water, in readiness for the shipments which will be necessary to deal with the 100 ton per day output. Mr. Gepp states that the company will be exporting annually 10,000 tons of zinc oxide, 15,000 tons of zinc-lead oxide, and from 10,000 to 15,000 tons of lithophone, with quantities of rolled zinc sheets and silver and lead in bullion, in addition to the daily output of 100 tons of zinc. At present 25 tons of zinc are being produced in addition to by-products, and it is anticipated that by next November the output will be 50 or 60 tons per day. [Owing to the low price of zinc, production has been suspended

since this letter was written, but the construction of new plant and buildings is still actively in hand.—EDITOR.] At present only 5,700 h.p. is delivered by the State Hydro-Electric Department, but when the full 30,000 h.p. contracted for is supplied and the 100-ton plant is in full operation, some 100,000 tons of concentrates will be imported yearly from Port Pirie and some 35,000 to 40,000 tons of zinc and about the same quantity of other products will be exported from Hobart, so it is evident that some shipping accommodation will be required. A power house is being built of reinforced concrete to contain seven rotary converters, and the full 30,000 h.p. will come here direct, and when the machinery on order from Rugby is installed the building will contain £150,000 worth of electrical equipment. This building will be 200 ft. long and 60 ft. wide, the walls being 40 ft. high. Six of the seven converters will be in constant use. Overhead cranes will be installed for the purpose of lifting out the machines for overhaul or repair in the adjacent workshop. A conveyor is being built which will take the concentrates on an endless 30 in. belt from the steamers to the bin, which will hold about 20,000 tons of concentrates. Distributing conveyors are also to be erected from the bins to the final roasters, and from there to the leaching plant, etc. Electric shovels are to be installed at the bin for lifting the concentrates on to the conveyors. A carpenter's shop is also being specially designed for the making of the 50 ft. vats used for the supply of solutions to the cell-room. The butcher's shop, now nearing completion, is replete with every modern convenience, and is fitted with a refrigerator chamber. This shop is being run in conjunction with the company's co-operative stores and under the direction of the employees' co-operative council, which deals with all matters relating to the health and recreation of the workers. The latest venture is the importation of machinery for the making of barrels of ply-wood. The ply will be cut from green myrtle timber, and the barrels will be used for exporting the by-products. The company has its own saw-mill and a large seasoning yard on the property.

A model village is being built on the slope of the hill near Prince of Wales Bay, and this has been laid out on the best garden-suburb lines, there being a perfect panorama of river, mountain, and orchards, with not the least suggestion of the deadly monotony of suburbia. A dozen different styles of houses have been built of concrete, in chalet and bungalow style, roofed with concrete tiles, corrugated iron, and shingles, and the tenants can take their choice. As the site was previously an orchard, the fruit is ready to be picked as the tenants take possession. Some 23 houses are already occupied, and as many more are nearing completion. Sixty are to be built on the orchard site, and another 120 are to follow on a site above the main road.

TORONTO.

January 12.

COBALT.—The production of silver has been greatly curtailed by the shortage of electric power. Only some 10 mines out of 19 that were being operated during the summer are now working, and it is doubtful as to whether they will be able to continue in operation until spring. But for the unusually mild weather which has so far prevailed, conditions would have been still more serious. Working forces have been considerably reduced at those mines which are still producing, and only about 1,000 men are now at work as compared with some 2,000 last summer. The wage scale, which has been maintained so far at the same rate which prevailed when the price of silver was high, will be reduced by 75c. per day or approximately 15% from February 15. Among the mines which have recently closed down are the Beaver and the McKinley-Darragh, both of which are being kept clear of water in readiness for the resumption of work as soon as power is available. The Nipissing is the only mine which has not reduced its output. During December it produced silver of an estimated net value of $299.894. Its production of cobalt metal during 1920 was valued at $224,204. At the Bailey a 2 in. vein of high-grade ore, running 4,000 oz. to the ton, recently discovered on the 240 ft. level, is being developed. During November the company made gross earnings of $13,668 from the treatment of 4,556 tons of ore. Three high-grade veins discovered on the surface of the Kerr Lake have proved disappointing under development, as the enrichment apparently extends only a few feet downward. A new company, entitled the Ruby Co-operative Silver Mines, Ltd., with a capitalization of $1,500,000, has been formed to operate the Ruby mine in Bucke township. High-grade ore has been encountered on the 100 ft. level. The annual report of the Coniagas showed an output of 994,235 oz. of silver from the treatment of 97,624 tons of ore, as compared with 940,267 oz. during the previous year. The mine is now solely dependent upon the concentration of ores averaging about 10 oz. to the ton, and the re-treating of accumulations of sands and slimes which yield a moderate profit. There has been

a total distribution to shareholders as dividends and bonuses of $10,140,000.

PORCUPINE.—The available supply of electric power for the mines, which is considered as assured for the winter, is only about 4,000 h.p., an amount far below normal requirements. This is being allotted to the mines which have contracts with the power company. The Hollinger Consolidated receives about 2,000 h.p. which, together with about 1,400 h.p. generated by its auxiliary steam plant, enables it to maintain a fair rate of production. The Dome mines with 1,000 h.p. is working at considerably reduced capacity, treating an average of about 500 tons daily. It is not expected that the decrease in output will interfere with the payment of the regular dividends, as activity will be resumed on a larger scale than ever in the spring. The McIntyre receives only a small allowance of power, but its auxiliary equipment enables the company to continue operations at about two-thirds capacity. The North Crown, which receives 250 h.p., is carrying on cross-cutting at the 500 ft. level, where two veins, one 5 ft. and the other 10 ft. in width, have been encountered. Negotiations are in progress with a view to an amalgamation of the North Crown and the Vipond-North Thompson, which would give the new company a combined area of 320 acres and enable important economies in working the properties to be carried out. The annual report of the Porcupine-Keora states that diamond-drilling shows that the gold content of about $6 per ton found in outcropping veins continues at a depth of 1,000 ft. The Clifton-Porcupine has suspended operations on account of the difficulties in the way of raising funds by selling treasury stock under present conditions.

KIRKLAND LAKE.—There has been a considerable influx of labour into this camp from Cobalt, and mining staffs have been increased. The Lake Shore, during November, treated 1,810 tons of ore with a recovery of $49,339, being an average of $27·25 per ton. The shaft is down to the 600 ft. level and sinking has been temporarily stopped until a cross-cut has been run at that depth to tap two veins. The Ontario-Kirkland is developing ore on the 300 ft. and 450 ft. levels, which assays from $8 to $28 per ton, and has enough in sight to supply the mill for two years. Machinery and supplies will be brought in during the winter and the construction of the mill will be pushed in the spring. The Kirkland Lake has made a shipment of gold bullion produced during December of the approximate value of $30,000. The King Kirkland has ordered a mining plant, and following its installation will begin the development of promising surface outcrops. Plans for a merger of the Teck-Hughes and Orr mines are being considered, involving the formation of a new company capitalized at $5,000,000 in shares of par value of $1. The Teck-Hughes interests, including the bondholders, will receive 2,500,000 shares, the Orr stockholders to get 1,500,000 shares, leaving the remainder in the treasury.

LARDER LAKE.—The Associated Goldfields has been reorganized under a new charter as the Canadian Associated Goldfields, Ltd., capitalized at $30,000,000, each stockholder receiving four shares of the new company for each share in the Associated Goldfields. George A. Gray, who was for several years chief engineer at the Dome Mines, Porcupine, has been appointed general manager.

MINERAL PRODUCTION OF 1920.—A preliminary estimate of the mineral production of Canada issued by the Department of Mines gives the total value as approximately $200,000,000 as compared with $176,686,390 in 1919. The principal increases are: copper from 75,053,581 lb. to 82,500,000 lb., zinc from 32,194,707 lb. to 42,000,000 lb., nickel from 44,544,883 lb. to 61,500,000 lb., and coal from 13,681,218 tons to 16,000,000 tons. The output of gold is estimated at $16,000,000, being a slight increase, and silver shows a decline from 16,020,657 oz. to 13,500,000 oz.

CAMBORNE.

THE TIN MINES.—The up and downs of Cornish mining are proverbial, but never, in the known history of the industry, has such a bad period as the present been experienced. The only mine, of any size at any rate, in full swing is East Pool & Agar, and here the monthly loss is such that unless there is a speedy recovery in the tin and arsenic markets, operations even at this famous mine will have to be brought to a standstill. [Since the above was written, notice has been issued for a stoppage of mining.—EDITOR.] Indeed, but for the financial foresight of the board in getting together a substantial reserve fund when handsome profits were being earned, it is clear that the company would not have been in a position to continue the struggle so long, and like many of the other concerns, weakened by the effects of the war, would ere this have been shut down, probably never to be reopened. South Crofty has suspended operations, but the mine is being kept unwatered and a little development done. Fortunately the pumping charges here

are light, so there is hope that absolute closure may be avoided, so long as East Pool continues in fork. At the latter mine, the incoming water is exceedingly heavy, particularly during the winter months, so that even if active mining operations were suspended, and only pumping continued, the monthly loss would still probably be over £5,000. The staff and employees at East Pool have agreed to a reduction in wages which will help matters a little, and we commend the good sense of the men and their leaders in their attitude in this matter. In the St. Just district, doubtless under the advice of the Union leaders (incidentally a different Union), the men have declined to accept any reduction, with the result that operations at Levant and Geevor have been suspended and the men are being forced to subsist on the unemployment donation. Under the circumstances, probably these companies are the gainers, but it is difficult to understand the attitude of the men, particularly when one remembers that they have always been most considerately treated by Mr. Oliver Wethered and his colleagues and that the rates of pay in the St. Just district were higher than elsewhere. At Tresavean and Porkellis, only the pumps will be kept working. With tin metal at £165 per ton, even alluvial undertakings cannot be operated at a profit with present working costs, so that there must surely be a recovery in price within the next few months. We hope it may be soon, for if not, the dirge of Cornish tin-mining will have to be sung. With coal at its present exorbitant price, and we note with dismay that a further increase is threatened, even pumping operations only cannot long be continued. No further move has been made to secure new capital for Dolcoath under the scheme outlined in the last issue, and this postponement is wise, for even local people would not have had the courage to put up more money under existing conditions. The difficulty will be to find the money to enable the water to be kept below the level of the proposed Roskear exploratory cross-cut, but we hope this may be done.

CHINA CLAY.—Tehidy Minerals, Ltd., has recently purchased the Halviggan china-clay works owned by Messrs. Pochin & Co., situated near St. Austell. The output of these pits is stated to be about 20,000 tons per annum. The terms of the purchase are not stated. Presumably, the company's own china-clay properties in this district will be worked in conjunction with Halviggan.

A new company is now to be formed to re purchase from Mr. Mallaby-Deeley the works of the China Clay Corporation on Dartmoor for the sum of £47,000. This is the actual price Mr. Deeley paid for the property at the recent sale. The new company will be capitalized at £75,000, so that £28,000 will be available as working capital, which is believed to be adequate, bearing in mind that close on £200,000 was spent by the previous owners on equipment and development.

Australia's Metal Output, 1920.

The Imperial Mineral Resources Bureau has received from its Corresponding Member in Australia cable information, from which the following table is prepared, relative to the mineral industry of the Commonwealth of Australia for the year 1920.

	Production. Tons.	Exports. Tons.	Imports Tons.	Home Consumption Tons.
Copper—				
(a) bar copper ...	23,069	28,612	—	5,231
(b) in blister copper	2,000	2,000	—	—
(c) in copper ore ...	115*	115	—	—
Lead –				
(a) lead	4,077	50,069	—	13,992
(b) in lead bullion ...	1,939	1,798	—	—
(c) in concentrates	4,122*	4,122	—	—
Zinc	9,665	5,689	—	6,456
Zinc Concentrates ..	—	52,732†	—	—
Tin	4,108	3,015	—	1,000‡
Pig iron	344,000	22,657	1,967	300,000§
Arsenic	1,202	582	—	—
	Ounces.	Ounces.		
Silver	701,177	341,901	—	—

*Exported. †Containing approximately 47% zinc, 7% lead, and 11 oz. silver per ton. ‡Approximate. §Estimated.

PERSONAL.

DR. FRANK DAWSON ADAMS has been appointed vice-principal of McGill University.

GEORGE RENNIE AIRTH has returned from Trinidad.

DR. J. MACKINTOSH BELL is here from Canada.

J. E. BREAKELL has returned to West Africa.

J. M. CAIRNS is back from Spain.

WILLIAM CALDER has left for Trinidad.

G. W. CAMPION has left London on his return to West Africa.

SIR W DALRYMPLE is here from South Africa.

CLEMENT DIXON has arrived from Rhodesia.

SIR GEORGE DOOLETTE, chairman of Great Boulder Proprietary, celebrated his 81st birthday on January 24.

C. H. FELDTMANN has been appointed metallurgist to the Colombian Mining & Exploration Co., and left on February 14.

DONALD GILL has left for France.

THOMAS GIRTIN has joined the board of Johnson, Matthey & Co., Ltd.

F. H. GRANSTEDT has been appointed manager of the Leviathan tin mine, New South Wales.

DR. EUGENE HAANEL is resigning the directorship of the Mines Branch of the Canadian Government under the age-limit regulation.

A. F. HASELTINE has been appointed principal of the Ballarat School of Mines.

(Continued on next page.)

LOFTUS HILLS, Government Geologist for Tasmania, is making an examination of the Mount Lyell region.

WILLIAM HOSKING, who was for twenty years mineral agent for the Tehidy Estate, when under the ownership of Mr. Basset, has opened an office as consulting mining engineer, at 18, Penventon Terrace, Redruth.

BERTRAM HUNT has joined the London staff of the Dorr Company as chemist and metallurgist.

P. F. KENDALL will be resigning the professorship of geology in Leeds University next June, under the age-limit. Professor Kendall is well known for his work in connection with the concealed coalfields of Yorkshire and the Midlands.

MARK R. LAMB, of New York, is visiting South America.

GEORGE C. MACKENZIE has been appointed secretary of the Canadian Institute of Mining and Metallurgy.

C. H. MACNUTT has resigned as manager of the Black Lake Asbestos & Chrome Co., Ltd., and is now in charge of the Vimy Ridge property of the Bennett-Martin Asbestos & Chrome Mines, Ltd., at Coleraine, Quebec.

ERIC NEWBOLD has gone to New Mexico.

DAVID PENMAN has been appointed principal and professor of mining in the new School of Mining and Geology to be founded at Dhanbad in the Bihar-Orissa coal-mining district, India.

C. W. PURINGTON is back from Okhotsk, far east Siberia.

H. K. SCOTT has returned from the Gold Coast.

J. E. SPURR, editor of the *Engineering and Mining Journal*, has been elected president of the Mining and Metallurgical Society of America.

W. C. STEPHENS, managing director of the Climax Rock Drill & Engineering Works, Ltd., is on his way home from the Rand.

G. W. EATON TURNER has returned from Colombia.

DR. ARTHUR WADE has returned from Australia, and is now acting as consulting engineer to the Commonwealth with office at 91, Basinghall Street, E C.

WILLIAM WHYTE, lately underground manager at the Messina mine, has gone to Colombia for the Colombian Mining & Exploration Company

OWEN B. WILLIAMS has been appointed manager of the North Mount Farrell mine, Tasmania.

JOHN BARRY, chairman of the California Exploration Co. and the Plymouth Consolidated Gold Mines, and a director of the Sons of Gwalia, died on January 27.

SIR LAZARUS FLETCHER, for so many years keeper of the mineral collection at the Natural History Museum, at South Kensington, and later Director of the Museum from 1909 to 1919, died last month.

DR. REGIS CHAUVENET, emeritus professor of chemistry at the Colorado School of Mines, Golden, Colorado, died on December 5, in his 78th year. Dr. Chauvenet was born in Philadelphia, on October 7, 1842. He graduated from Washington University in 1862 with the degree of Bachelor of Arts, and in 1864 he received the degree of Master of Arts. In 1867 he received the degree of Bachelor of Science at Harvard. In 1900 his alma mater conferred upon him the degree of Doctor of Laws. From 1871 to 1883 Dr. Chauvenet had an office in St. Louis as an analytical chemist, and was not only successful in a financial way, but won a wide reputation technically. During this time he was chemist to the Missouri Geological Survey. From 1872 to 1875 he was also city gas inspector for St. Louis. In 1883 he was called to the Colorado School of Mines as president and professor of chemistry and metallurgy. It was largely through his high educational ideals and efforts that the School won its place among the institutions of higher learning of the world. In 1902, after a service of twenty years, he resigned and again entered private practice as a consulting engineer and chemist, with offices in Denver. Though resigning as active head of the School, for many years he was a special lecturer in the chemistry and metallurgy departments. During the latter years of his life he devoted most of his time to writing a history of the School. In 1911 he issued a volume on "Chemical and Metallurgical Calculations" which enjoyed a wide circulation.

TRADE PARAGRAPHS

HENRY BATH & SON, LTD., of 53, New Broad Street, London, E.C.2, Swansea, and Liverpool, send us their chart giving the average monthly cash prices of copper, tin, lead, and spelter.

A. GALLENKAMP & CO., LTD., of 19 & 21, Sun Street, Finsbury Square, London, E.C.2, send us their catalogues of filter papers and porcelain and glass ware for laboratory purposes

N. TAYLOR & SONS, of 17, Goree Piazzas, Liverpool, send us their pamphlet relating to hydro-carbonated bone-black for case-hardening, which gives a description of the process.

SANDYCROFT, LTD., of Chester, and 4, Broad Street Place, London, E.C.2, have acquired from Chalmers & Williams, Chicago, the sole licence for manufacturing the Symons Disc Crusher in England.

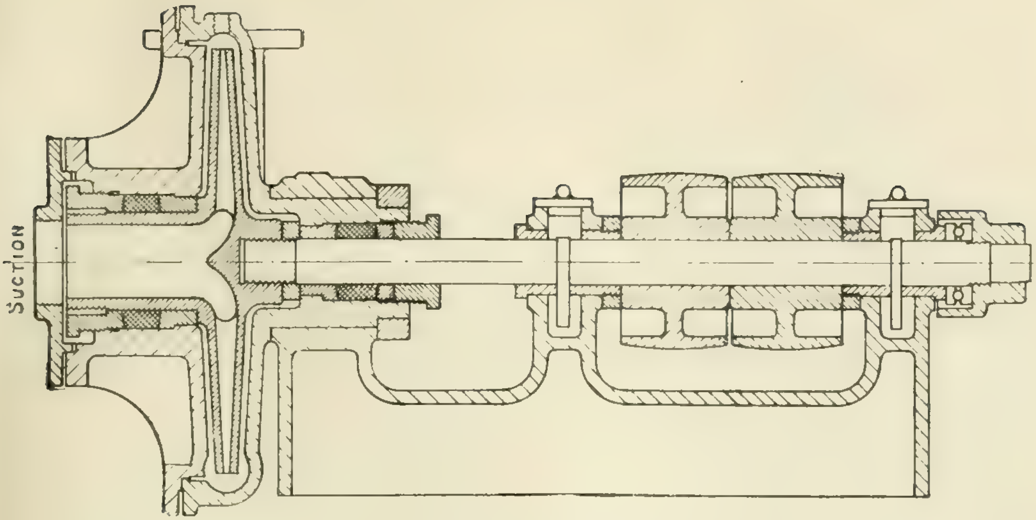
THE CONSOLIDATED PNEUMATIC TOOL CO., LTD., of 170, Piccadilly, London, W.1, have appointed J. A. Angus, of Kaims Foundry, Strand Road, Rangoon, their agent for Burma.

THE EDGAR ALLEN NEWS for January-February contains a number of interesting articles. One is by C. K. Everitt describing special steel processes; a second gives information relating to instruments for measuring temperatures in heat treatment of steel; a third is devoted to the application of the Stag ball-mill to the production of fine stone-dust used in dusting the roads of collieries.

THE BRITISH ROPEWAY ENGINEERING CO., LTD., of 34, Fenchurch Street, London, E.C.3 (purchasers from the Government Controller of Bleichert's Aerial Transporters, Ltd.), send us a pamphlet describing the application of their ropeway to the automatic disposal of refuse of all descriptions. In mining it is applicable for the dumping of tailings and waste rock, refuse from coal washers, etc.

THE INTERNATIONAL BARGE SUPPLY & TRANSPORT CO., LTD., of 5, Lloyds' Avenue, London, E C.3, send us a pamphlet describing their barges, which are built of steel, and are suited for propulsion by petrol engines or for towing purposes. Each barge is divided longitudinally into four sections, so that a number of them can be packed in one big motor-driven barge for transport to their destination abroad. The sections can be easily put together on arrival.

THE STURTEVANT ENGINEERING CO., LTD., of 147, Queen Victoria Street, London, E.C.4, send us a book describing their installations of machinery for making superphosphate manures. The preparing plant described includes vertical rotary crushers, ring-roll mills, Newaygo screens, air separators, dust collectors, etc., and jaw crushers and rolls for breaking iron pyrites. The book also describes the plant for producing superphosphate by acting on the phosphate with sulphuric acid.



THE WILFLEY CENTRIFUGAL PUMP.

THE WILFLEY CO., LTD., of Salisbury House, London, E.C.2, send us particulars of a new type of centrifugal pump which they are putting on the market. The pump differs from that of the ordinary type in that the impeller is fitted with a hollow trunnion through which the suction water passes on its way to the impeller passages, and the trunnion itself runs in a packed gland, with the result that leakage of water from the delivery to the suction side is prevented, a source of loss liable to occur in centrifugal pumps of ordinary design. Owing to the water entering on one side only of the impeller there is an end thrust which is taken by a ball thrust-bearing on the driving shaft. The main dimensions of the pump are: Diameter of impeller, 12 in.; diameter of interior of trunnion, 1·75 in.; angle of blades, 20°; diameter of suction pipe, 2½ in.; diameter of delivery pipe, 2 in. Tests made by Professor John Goodman, of Leeds, showed that the pump lifted a maximum of 111½ gallons to 125 ft. at a low speed of 1,500 r.p.m., and 193 gallons to 53 ft. at a speed of 1,320 r.p.m. A suction lift of 33 ft. water was obtained at 1,590 r.p.m. with the barometer standing at 35·5 ft. It is believed that no centrifugal pump has lifted previously more than about 20 ft. suction, and the usual total lift in one stage does not exceed about 80 ft. The efficiencies obtained were, it is believed, greater than could be obtained with so small a pump of the ordinary type, while such high lifts could only be reached by multi-stage pumps of high-grade construction. The pump tested by Professor Goodman is quite rough, and there is no internal machining of the case or the impeller, excepting that the trunnion of the impeller, which is the novel feature, is of course turned to fit the stuffing box glands.

METAL MARKETS

COPPER.—Prices of this metal declined further during the month of January, this remark applying to both standard and electrolytic copper in this country. So far as the price of electrolytic is concerned, the fall is, of course, largely on account of the improvement in the rate of dollar exchange, as, so far as the American market is concerned, things have not on balance become any easier during the period in question. Indeed at one time some firmness was in evidence there, and there seemed to be a little more doing, but latterly this apparent spasm of strength evaporated. Generally speaking the whole copper situation has not very materially altered. The stocks on hand in America are still big. The exact quantity is not known, and various estimates are put forward, one being that there is about 390 000 tons of copper in existence there, this of course doubtless including blister copper as well as the refined product. In the meanwhile consumption everywhere remains on a very restricted scale. It is difficult to form an estimate as to the future of the market. On this side the price depends to a large extent on whether the recent improvement in the dollar exchange is maintained. There is a general movement in America to curtail production, but of course it must be a little time before this becomes evident. This, however, should help the market in the long run. For example, the Calumet and Arizona, it is stated, has now reduced output to between 35 and 40% of capacity. Until the last two or three months of 1920 curtailment did not materially affect the company's cost, the production figure averaging about 13½ cents. Under the new basis it is expected that the cost will show some expansion. Curtailment is also evident in the December production figures of the four Jackling porphyry-copper companies. With an output of 7,500 000 lb. of copper the Utah company is producing at the rate of 90,000,000 lb. a year, while in 1917 the company produced 197,837,111 lb. of metal. Chino is now producing at the rate of 36,000,000 lb. of copper annually, compared with 79,636 000 in 1917. Ray has reduced output 60% below the 1917 rate. Nevada Consolidated's indicated annual output is 56% less than the big war year. These reductions in output will presumably tend to increase the per-lb. cost, but on the other hand it should be remembered that wages and other costs are meanwhile declining, which should therefore off-set this increase. At the beginning of this year, for example, the American Smelting and Refining Co. reduced wages to the extent of 2,000,000 dollars per annum as well as cutting off another 500 000 dollars a year through the curtailment of forces, while it is admitted that the general dropping of prices will greatly assist the supply department. There are reports that arrangements have been made in America for the financing of a part of the stocks, presumably the export-

DAILY LONDON METAL PRICES: OFFICIAL CLOSING
Copper, Lead, Zinc, and Tin per Long

COPPER

	Standard Cash	Standard (3 mos.)	Electrolytic	Wire Bars	Best Selected
Jan.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.
11	74 0 0 to 74 2 6	74 0 0 to 74 2 6	81 0 0 to 83 0 0	82 0 0 to 83 0 0	79 0 0 to 80 0 0
12	74 0 0 to 74 5 0	73 15 0 to 73 17 6	81 0 0 to 83 0 0	82 0 0 to 83 0 0	79 0 0 to 80 0 0
13	73 17 6 to 74 0 0	73 12 6 to 73 17 6	81 10 0 to 83 10 0	82 10 0 to 83 10 0	79 0 0 to 80 0 0
14	73 0 0 to 73 5 0	72 15 0 to 73 0 0	81 0 0 to 83 0 0	82 0 0 to 83 0 0	79 0 0 to 80 0 0
17	72 0 0 to 72 5 0	71 15 0 to 72 0 0	80 0 0 to 82 0 0	81 0 0 to 82 0 0	79 0 0 to 80 0 0
18	70 7 6 to 70 10 0	70 7 6 to 70 10 0	79 0 0 to 81 0 0	80 0 0 to 81 0 0	76 15 0 to 77 5 0
19	70 5 0 to 70 7 6	70 7 6 to 70 10 0	79 0 0 to 81 0 0	80 0 0 to 81 0 0	76 15 0 to 77 5 0
20	70 0 0 to 70 5 0	70 2 6 to 70 7 6	79 0 0 to 81 0 0	80 0 0 to 81 0 0	76 15 0 to 77 5 0
21	69 5 0 to 69 7 6	69 10 0 to 69 12 6	79 0 0 to 80 0 0	79 0 0 to 80 0 0	76 0 0 to 77 0 0
24	67 15 0 to 67 17 6	68 0 0 to 68 5 0	78 0 0 to 79 0 0	78 0 0 to 79 0 0	76 0 0 to 77 0 0
25	67 0 0 to 67 5 0	67 5 0 to 67 10 0	76 0 0 to 78 0 0	76 0 0 to 78 0 0	73 0 0 to 74 0 0
26	68 2 6 to 68 7 6	68 10 0 to 68 15 0	77 0 0 to 78 0 0	77 0 0 to 78 0 0	73 0 0 to 74 0 0
27	69 10 0 to 69 15 0	70 2 6 to 70 5 0	77 0 0 to 79 0 0	77 0 0 to 79 0 0	73 0 0 to 74 0 0
28	67 15 0 to 68 0 0	68 5 0 to 68 10 0	76 0 0 to 78 0 0	76 0 0 to 78 0 0	74 0 0 to 75 0 0
31	67 15 0 to 68 0 0	68 5 0 to 68 10 0	75 10 0 to 77 0 0	75 10 0 to 77 0 0	74 0 0 to 75 0 0
Feb.					
1	69 10 0 to 69 15 0	70 0 0 to 70 5 0	76 0 0 to 77 10 0	76 0 0 to 77 10 0	74 10 0 to 75 10 0
2	69 5 0 to 69 10 0	69 15 0 to 70 0 0	76 0 0 to 77 10 0	76 0 0 to 77 10 0	74 10 0 to 75 10 0
3	68 5 0 to 68 7 6	68 17 6 to 69 0 0	76 0 0 to 77 10 0	76 0 0 to 77 10 0	74 10 0 to 75 10 0
4	69 15 0 to 70 0 0	70 5 0 to 70 10 0	76 10 0 to 78 0 0	76 10 0 to 78 0 0	75 0 0 to 75 10 0
7	72 0 0 te 72 5 0	72 7 6 to 72 10 0	77 0 0 to 79 0 0	77 0 0 to 79 0 0	75 0 0 to 75 10 0
8	72 0 0 to 72 5 0	72 10 0 to 72 15 0	78 0 0 to 80 0 0	78 0 0 to 80 0 0	76 10 0 to 77 10 0
9	72 0 0 to 72 5 0	72 10 0 to 72 15 0	78 0 0 to 80 0 0	78 0 0 to 80 0 0	76 10 0 to 77 10 0

able surplus. What effect this will have on the market is hard to say.

Average prices of cash standard copper: January 1921, £71. 1s. 4d.; December 1920, £75. 16s. 8d.; January 1920, £118. 4s. 1d.; December 1919, £103. 17s. 1d.

TIN.—The chief feature in this market during the past month was the severe slump in prices of standard tin which took place in the latter part of the month. It is difficult to ascribe the fall to any one particular reason, except that the general demand for tin has been poor, and a considerable amount of liquidation, apparently on the part of tired bulls, appeared on the market, with the result that in the absence of any determined support values lost ground heavily. In the meanwhile no business has been moving in the Straits Settlements where the price remains pegged at the equivalent of £236 per ton delivered to this country. In view of the fact that Straits tin there was well held, the stocks of that grade which are in existence in this country have been fetching a considerable premium over the price of standard tin, this ranging at one time up to £25 per ton. Even, however, when this figure is added on to the price of standard it is very considerably less than the price at which the same material could be purchased in the East. Of course the market for standard, and the market for Straits, have really come to be two different propositions, the bulk of the dealings in the former being based on the stocks of Chinese and English tin, premiums being obtained for both Banka and Australian metal, as well as for Straits, as already mentioned. In view, however, of the severe drop in prices here, there has been a general feeling that some change in policy would have to be adopted in the Straits. The Government there took up the attitude they did with a view to keeping the industry going, and preventing unemployment and discontent. There is, however, a belief that some change will take place at the Chinese New Year, but no news is yet to hand. In the meanwhile a growing demand has been experienced from the Continent, but business with home consumers is slow, and, although a certain amount of trade has been doing with America, on the whole it did not amount to a sufficiently important demand to give any material support to the market.

Average prices of cash standard tin: January 1921, £190. 13s. 11d.; December 1920, £212. 11s. 8d.; January 1920, £376 12s. 8d.; December 1919, £314. 5s. 1d.

LEAD.—During the month of January this market maintained a very steady tone on the whole, and was not so affected by the general depression as were other metals. Copper, tin, and spelter may be said to have fallen to a pre-war level, but lead still remains at a comparatively high figure as compared to what used to be considered normal. This seems all the more surprising in view of the fact that business with consumers has been on a very restricted scale indeed, and the firmness must be chiefly ascribed to the fact that the arrivals coming in recently have been rather reduced. There is a very considerable stock of lead in this country, but this seems to be well held. A part of it consists of the Government stock, which is believed to be partly Broken Hill lead which they appear anxious to conserve for home requirements and are not selling it for shipment abroad. In a manner this is unfortunate, as there has been a good deal of inquiry from the East for this brand which has had to be turned down. Meanwhile, owing to the impossibility of securing Broken Hill lead, the Eastern markets seem to be drawing upon Burma for supplies. Spain does some selling there from time to time, and recently it is understood that some American lead has also been sold there. It must not be forgotten that the world is being deprived of its usual supplies of Broken Hill lead, and this looks like continuing, a serious fire having occurred at the smelting works at Port Pirie, where it is estimated the damage amounts to about £100,000.

Average prices of lead: January 1921, £23. 12s. 6d.; December 1920, £24. 11s. 10d.; January 1920, £47. 7s. 1d.; December 1919, £41. 7s. 8d.

SPELTER.—During the month of January prices of this metal eased off to a certain extent, but on the whole the market kept up a fairly steady tone, this being apparently due to a certain amount of buying being done here on behalf of the United States. There is a big stock of spelter in America, and this buying was solely owing to the fact that the metal could be bought cheaper here than there. Apart from this there has not been very much demand for the metal, the consumption everywhere being very poor on account of the slack conditions in the galvanized sheet trade, and indeed in business generally. In the meanwhile a cer-

PRICES ON THE LONDON METAL EXCHANGE.
Tons; Silver per Standard Ounce; Gold per Fine Ounce.

Lead: Soft Foreign	Lead: English	Zinc (Spelter)	Standard Tin: Cash	Standard Tin: 3 mos.	Silver: Cash	Silver: Forward	Gold	
£ s. d. £ s. d.	£ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.			s. d	Jan.
23 15 0 to 24 5 0	26 0 0	26 15 0 to 27 10 0	209 0 0 to 209 10 0	213 15 0 to 214 5 0	39½	39⅜	108 10	11
23 10 0 to 24 0 0	25 10 0	26 10 0 to 27 7 6	205 0 0 to 205 10 0	210 15 0 to 211 0 0	40	39⅞	108 11	12
23 5 0 to 23 12 6	25 10 0	26 0 0 to 26 15 0	205 0 0 to 205 10 0	211 0 0 to 211 5 0	39¾	39⅝	110 6	13
23 10 0 to 24 0 0	25 10 0	24 17 6 to 26 0 0	200 0 0 to 200 10 0	204 10 0 to 205 0 0	40	39¾	109 8	14
23 5 0 to 23 5 0	25 0 0	24 10 0 to 25 15 0	191 0 0 to 191 10 0	196 0 0 to 196 10 0	39⅞	39¾	109 9	17
22 17 6 to 23 5 0	25 0 0	24 0 0 to 25 5 0	180 10 0 to 181 0 0	185 10 0 to 186 0 0	39¾	39½	108 9	18
22 17 6 to 23 5 0	25 0 0	24 5 0 to 25 5 0	181 10 0 to 182 0 0	187 0 0 to 187 10 0	39½	39⅜	109 5	19
23 0 0 to 23 7 6	25 5 0	25 0 0 to 26 0 0	187 0 0 to 187 5 0	191 15 0 to 192 0 0	40⅜	40½	108 9	20
23 5 0 to 23 15 0	25 0 0	25 10 0 to 26 10 0	179 10 0 to 180 0 0	184 10 0 to 185 0 0	40	39¾	109 0	21
23 2 6 to 23 10 0	25 0 0	24 15 0 to 26 0 0	171 10 0 to 172 0 0	177 5 0 to 177 10 0	40	39⅜	108 6	24
23 5 0 to 23 15 0	25 0 0	24 5 0 to 25 5 0	164 0 0 to 164 5 0	169 15 0 to 170 0 0	39¾	39¼	107 4	25
23 12 6 to 24 2 6	25 10 0	24 5 0 to 25 5 0	169 0 0 to 169 10 0	175 0 0 to 175 10 0	40	38⅞	107 9	26
23 5 0 to 23 15 0	25 0 0	24 0 0 to 25 0 0	174 10 0 to 175 0 0	180 10 0 to 181 0 0	39⅝	38¼	106 3	27
23 5 0 to 23 12 6	25 0 0	24 0 0 to 25 0 0	167 10 0 to 168 0 0	173 0 0 to 173 10 0	37¾	37¼	105 7	28
23 2 6 to 23 15 0	25 0 0	24 15 0 to 25 15 0	168 10 0 to 169 0 0	174 10 0 to 175 0 0	35⅛	34⅝	106 1	31
								Feb.
23 5 0 to 23 10 0	25 0 0	24 10 0 to 25 10 0	168 10 0 to 168 15 0	173 15 0 to 174 0 0	34⅛	34	107 2	1
22 15 0 to 23 5 0	24 10 0	24 0 0 to 25 0 0	162 10 0 to 163 0 0	168 15 0 to 169 0 0	36¼	35¼	107 0	2
22 10 0 to 23 0 0	24 10 0	23 15 0 to 24 15 0	155 10 0 to 156 0 0	161 10 0 to 162 0 0	37¼	36⅜	106 9	3
22 15 0 to 23 5 0	24 10 0	24 5 0 to 25 0 0	164 0 0 to 164 10 0	169 5 0 to 169 10 0	36¼	34¼	106 9	4
22 12 6 to 23 2 6	24 10 0	24 15 0 to 25 10 0	166 10 0 to 167 0 0	172 0 0 to 172 10 0	36	34¾	107 0	7
22 10 0 to 22 17 6	24 10 0	25 7 6 to 26 7 6	164 0 0 to 164 10 0	169 0 0 to 169 10 0	36⅛	34¾	106 6	8
22 5 0 to 22 17 6	24 0 0	25 17 6 to 26 17 6	161 15 0 to 162 0 0	167 5 0 to 167 10 0	37	35	106 0	9

tain amount of selling has been seen both by Germany and Belgium, but it is understood that the Belgians are now putting a policy of curtailment of production into effect. The outlook is still rather obscure. It must be admitted that the price of spelter is very moderate indeed, but in view of the general absence of demand it might still be forced lower on account of selling by the Continent. On the other hand consumers are probably very poorly supplied, and when trade revives values would no doubt firm up quickly.

Average prices of spelter: January 1921, £25. 15s. 7d.; December 1920, £28. 11s. 6d.; January 1920, £59. 10s. 4d.; December 1919, £53. 9s. 2d.

ZINC DUST.—This market is very quiet and without much change. High-grade Australian stands at about £70 to £80 per ton, and English at about £70 to £80, while American is quoted at £70 upwards. There is, of course, Continental material offering at less money.

ANTIMONY.—The price of English has been reduced, and now stands at £37 to £40 per ton for ordinary brands, while special brands are quoted at £38. 5s. to £42 per ton. The market for foreign has been easier also, with a good deal of irregularity in quotations. Offers are reported to have been made at down to £24 per ton c.i.f. for shipment from the East.

ARSENIC.—The market is practically stagnant, and the present quotation of Cornish white is about £55 per ton delivered.

BISMUTH.—The price is steady at about 12s. 6d. per lb. with a fair demand.

CADMIUM.—The present quotation is about 6s. 3d. per lb., the market being quiet.

ALUMINIUM.—Prices continue to be quoted at £165 per ton for home and export.

NICKEL.—The price has been reduced by £5 per ton to £210 per ton for home and export.

COBALT METAL.—Unaltered at about 27s. to 30s. per lb.

COBALT OXIDE.—The price of black oxide has been reduced to 16s. and grey to 17s. 6d. per lb.

PLATINUM AND PALLADIUM.—The official price is £19 per oz. for both these articles, but apparently material can be had at around £16.

QUICKSILVER.—The market has been very quiet, at about £12. 10s. to £12. 15s. per bottle.

SELENIUM.—The price continues at 10s. 6d. to 13s. per lb.

TELLURIUM.—The current quotation is 90s. to 95s. per lb.

SULPHATE OF COPPER.—The market is quiet and without much change, the present price being quoted at £38 to £40 per ton.

MANGANESE ORE.—The quotation is about 2s. 1d. to 2s. 2d. per unit c.i.f. U.K. for Indian grades, but this is more or less nominal in the absence of business.

TUNGSTEN ORES.—There is little or no demand, and the present price of wolfram is about 15s. 6d. to 16s. 6d. per unit c.i.f.

SILVER.—On January 3 the price of spot standard bars was 41⅞d., this figure rising to 42½d. on the 5th. Subsequently quotations fluctuated, with a downward tendency, the figure at the end of the month being 35⅛d. per oz.

GRAPHITE.—Soft velvety flake 85% to 90% stands at about £60 to £80 per ton, and Madagascar 80% to 90% at about £21 to £25 per ton.

MOLYBDENITE.—85% is quoted at about 65s. on spot and 55s. for forward per unit c.i.f. U.K.

CHROME ORES.—48% to 52% stands at about £7. 10s. per ton c.i.f.

IRON AND STEEL.—The fall in prices which has been so long expected is now beginning to take more tangible shape. Prices of Cleveland pig iron were reduced and now stand at £9. 15s. to £10 per ton for No. 3 foundry. East Coast hematite has also come down to 220s. with No. 1 at 2s. 6d. per ton more. These reductions do not appear, however, to have stimulated very much business, and consumers everywhere appear to wait for still lower prices, and in this it does not look as if they would be disappointed. Prices of certain descriptions of steel and manufactured iron have also come down, but in no case does very much fresh buying seem to have been stimulated, the fact being that Continental prices are still very considerably lower. With general world trade conditions in the stagnant condition they have been, it is useless to expect any activity in this particular branch of industry, and in any case, with further price reductions apparently inevitable, it was hardly to be expected that any buying of importance would develop.

STATISTICS.

PRODUCTION OF GOLD IN THE TRANSVAAL

	Rand	Elsewhere	Total	Price of Gold per oz.
	Oz	Oz	Oz.	s d
Year 1919	8,111,271	218,820	8,330,091	
January, 1920	653,295	17,208	670,503	107 6
February	607,918	17,412	625,330	110 0
March	689,645	17,391	707,036	105 0
April	667,926	19,053	686,979	102 6
May	681,551	17,490	699,041	105 0
June	699,199	16,758	715,957	102 6
July	718,521	17,578	736,099	105 0
August	683,604	18,479	702,083	112 6
September	665,486	16,687	682,173	115 0
October	645,819	16,653	662,472	117 6
November	618,525	15,212	633,737	117 6
December	617,549	14,666	632,215	115 0
Total, 1920	7,949,038	204,587	8,153,625	—

NATIVES EMPLOYED IN THE TRANSVAAL MINES.

	Gold mines	Coal mines	Diamond mines	Total
January 31, 1920	176,390	12,766	4,796	193,952
February 29	185,185	12,708	5,217	203,110
March 31	188,564	12,788	5,232	206,584
April 30	189,446	12,951	5,057	207,454
May 31	184,722	12,897	4,793	202,412
June 30	179,827	13,036	4,596	197,459
July 31	174,187	13,005	4,521	191,713
August 31	169,263	13,535	4,244	187,042
September 30	163,132	13,716	4,323	181,171
October 31	159,426	13,858	4,214	177,498
November 30	158,773	14,245	3,504	176,522
December 31	159,671	14,263	3,340	177,274

COST AND PROFIT ON THE RAND

Compiled from official statistics published by the Transvaal Chamber of Mines. The profit available for dividends is about 65% of the working profit. Figures for yield and profit for 1919 based on par value of gold; subsequently gold premium included.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s d	s d	s. d.	£
October, 1919	2,108,698	28 3	22 6	5 10	612,841
November	1,933,526	28 8	23 5	5 5	521,472
December	1,845,088	28 8	25 6	3 10	354,098
Year 1919	24,043,638	28 7	22 11	5 6	6,605,509
January, 1920	2,038,092	34 4	24 2	10 2	1,036,859
February	1,869,180	35 1	28 3*	6 10*	644,571*
March	2,188,104	31 8	25 2	6 6	716,610
April	2,065,446	31 5	26 3	5 2	533,940
May	2,117,725	31 9	25 11	5 10	618,147
June	2,146,890	31 10	25 2	6 8	692,510
July	2,194,050	33 6	24 6	9 0	98[illegible],058
August	2,057,560	36 11	25 0	11 11	1,226,906
September	1,950,410	38 11	25 6	13 5	1,276,369
October	1,871,140	39 9	26 1	13 8	1,278,385
November	1,794,710	40 2	26 3	13 1	1,255,749

* Results affected by the back-pay disbursed in accordance with new wages agreement.

PRODUCTION OF GOLD IN RHODESIA AND WEST AFRICA.

	Rhodesia 1919	Rhodesia 1920	West Africa 1919	West Africa 1920
	£	oz.	£	
January	211,917	43,428	104,063	
February	220,885	44,237	112,616	
March	225,808	45,779	112,543	
April	213,160	47,000	109,570	
May	218,057	46,266	100,827	No official returns published.
June	214,215	45,054	106,612	
July	214,919	46,208	102,467	
August	207,339	48,740	103,112	
September	223,719	45,471	100,401	
October	204,184	47,343	91,352	
November	186,462	46,782	98,322	
December	158,835	46,190	98,806	
Total	2,499,498	552,498	1,240,691	

TRANSVAAL GOLD OUTPUTS.

	December Treated	December Yield	January Treated	January Yield
	Tons	Oz.	Tons	Oz.
Aurora West	8,800	£14,414†	9,100	£13,064*
Brakpan	47,100	21,489		
City Deep	73,500	31,868	83,500	35,867
Cons. Langlaagte	38,100	£68,055†	38,000	£61,172*
Cons. Main Reef	45,100	15,562	47,000	16,243
Crown Mines	175,000	52,967	185,000	52,018
Durban Roodepoort Deep	21,500	7,286	26,450	8,714
East Rand P.M.	107,000	30,531	116,000	30,716
Ferreira Deep	31,600	9,808	32,500	10,112
Geduld	43,000	15,213	45,000	15,644
Geldenhuis Deep	46,900	12,657	44,300	12,635
Glynn's Lydenburg	3,015	£7,688‡	3,184	£6,203*
Goch	15,350	£19,542†	16,100	£19,390*
Government G.M. Areas	128,500	£311,797†	132,500	£280,930*
Kleinfontein	45,000	13,332	47,060	12,868
Knight Central	22,400	6,227	23,000	6,013
Knights Deep	—	—	—	—
Langlaagte Estate	36,000	£63,494†	38,300	£62,492*
Luipaard's Vlei	15,130	£19,786†	—	—
Meyer & Charlton	12,760	£46,282†	13,700	£43,135*
Modderfontein	90,000	43,0[illegible]2	91,000	43,560
Modderfontein B	51,500	25,47[illegible]	55,000	26,540
Modderfontein Deep	41,200	22,299	42,600	22,864
Modderfontein East	25,700	10,631	25,700	10,572
New Unified	10,800	£14,187†	11,300	£13,239
Nourse	40,500	12,536	42,700	13,550
Primrose	19,000	£23,024†	19,500	£21,879*
Princess Estate	—	158	—	—
Randfontein Central	105,000	£176,152†	117,000	£176,773*
Robinson	38,700	7,442	38,000	7,892
Robinson Deep	47,300	12,820	50,100	14,435
Roodepoort United	22,200	£25,969†	22,800	£22,956*
Rose Deep	49,400	11,690	53,800	12,414
Simmer & Jack	58,400	13,250	61,500	13,193
Springs	37,600	16,897	—	—
Sub Nigel	9,000	5,459	9,700	5,265
Transvaal G.M. Estates	15,750	£30,007‡	16,650	£25,746*
Van Ryn	30,600	£54,603†	30,750	£48,763*
Van Ryn Deep	47,600	£138,319†	49,800	£137,046*
Village Deep	45,300	13,646	47,700	14,567
Village Main Reef	—	—	—	—
West Rand Consolidated	31,100	£51,828†	33,400	£50,444*
Witwatersrand (Knights)	31,000	£52,007†	31,700	£46,352*
Witwatersrand Deep	30,530	£51,753†	—	—
Wolhuter	31,500	8,378	32,500	7,617

* £5. 5s. 0d. per oz. † £5. 15s. 0d. per oz.
‡ £5. 18s. 9d. per oz

WEST AFRICAN GOLD OUTPUTS.

	November Treated	November Value	December Treated	December Value
	Tons	Oz.	Tons	Oz.
Abbontiakoon	5,492	£9,546*	5,029	£11,175*
Abosso	4,280	1,714	5,440	2,178
Akoko	210	158	206	156
Ashanti Goldfields	5,018	5,805	5,110	3,251
Obbuassi	660	£3,085*	670	£2,586†
Prestea Block A	8,670	£15,490*	8,545	£16,523*
Taquah	2,211	1,243	2,720	1,500

* At par. † Including premium.

RHODESIAN GOLD OUTPUTS.

	November Treated	November Oz.	December Treated	December Oz.
	Tons		Tons	
Falcon	15,013	2,735*	15,130	2,991‖
Gaika	3,933	1,333	3,558	1,175
Globe & Phœnix	5,759	7,875	5,560	7,611
London & Rhodesian	—	—	3,844	£2,467†
Lonely Reef	5,350	5,298	5,280	5,115
Planet Arcturus	5,650	2,985	5,900	2,713
Rezende	5,700	2,538	5,700	2,513
Rhodesia, Ltd.	—	—	—	—
Rhodesia G.M. & I.	630	294	660	228
Shamva	45,050	£46,1[illegible]8§	50,300	£41,312‡
Transvaal & Rhodesian	1,500	£4,[illegible]00†	1,500	£5,275†

* Also 251 tons copper. § Gold at 115s. per oz. ‖ Also 255 tons copper. ‡ Gold at 105s. per oz. † At par.

West Australian Gold Statistics.—Par Values.

	Reported for Export oz.	Delivered to Mint oz.	Total oz.	Total value £
October, 1919	586	64,987	65,573	278,535
November	1,171	64,823	65,994	280,323
December	831	27,334	28,165	162,575
January, 1920	836	25,670	26,506	112,590
February	1,928	49,453	51,381	218,251
March	—	54,020	54,020	229,461
April	835	56,256	57,091	242,506
May	227	50,976	51,203	217,495
June	502	56,679	57,181	242,638
July	—	48,341	48,341	205,340
August	167	54,258	54 425	231,185
September	141	54,940	55,081	233,963
October	174	53,801	53,975	229 275
November	128	54,729	54,857	233,017
December	321	53,595	53,916	229,057
January, 1921	523	50,934	51,457	218,574

Australian Gold Returns.

	Victoria.		Queensland.		New South Wales	
	1919	1920	1919	1920	1919	1920
	£	Oz.	£	Oz.	£	£
January	36,238	7,105	37,100	4,724	18,000	28,000
February	46,955	8,677	43,330	7,200	24,000	15,000
March	40,267	24,126	48,000	6,973	16,000	22,000
April	63,818	6,368	61,200	8,368	24,000	12,000
May	37,456	13,263	38,200	8,432	16,000	13,800
June	41,465	15,707	44,600	13,725	17,000	8,700
July	37,395	12,782	42,060	9,596	22,000	17,410
August	51,564	12,809	49,700	9,973	20,000	17,168
September	76,340	13,973	37,120	11,789	13,000	13,872
October	39,018	13,432	36,100	9,300	28,000	24,752
November	40,735	9,245	32,720	10 200	51,000	16,907
December	63,311	15,305	44,500	—	31,000	18,137
Total	575,260	152,792	514,630	100,201	280,000	207,746

Australasian Gold Outputs.

	November		December	
	Treated	Value	Treated	Value
	Tons	£	Tons	£
Associated G.M. (W.A.)	5,865	8,894	5,069	6,050
Blackwater (N Z.)	2,685	3,804	2,700	5,822
Bullfinch (W.A.)	5,380	1,467‡	5,500	5,738
Cock's Pioneer (V.)	—	—	—	—
Golden Horseshoe (W.A.)	10,608	4,717‡	5 064	1,945‡
Great Boulder Pro. (W.A.)	8,472	29,603	4,479	18,251‖
Ivanhoe (W.A.)	12,461	5,117‡	6,960	2,760‡
Kalgurli (W.A.)	3,038	3,945	2,707	4,642‖
Lake View & Star (W.A.)	9,063	11,282†	5,330	11,995†
Menzies Con. (W.A.)	1,570	2,906	1,160	2,132
Mount Boppy (N.S.W.)	5,636	7,070	5,385	2,283‡
Oroya Links (W.A.)	1,726	9,424†	1,461	10,649†
Progress (N.Z.)	—	—	—	—
Sons of Gwalia (W.A.)	10,373	13,302	12,917	15,806‖
South Kalgurli (W.A.)	7,058	12,643	4,308	9,64[illegible]‖
Waihi (N.Z.)	13,103	3,576‡ 30,323§	11,393	4,192‡ 23,993§
Waihi Grand Junc'n (N.Z.)	7,760	2,391‡ 10,753§	5,630	2,384‡ 11,153§
Yuanmi (W.A.)	1,540	3,591	1,460	5,029*

† Including royalties; ‡ Oz. gold; § Oz silver; ‖ At par.
* Including premium.

Miscellaneous Gold and Silver Outputs.

	November		December	
	Treated	Value	Treated	Value
	Tons	£	Tons	£
Brit. Plat & Gold (C'lbia)	—	—	—	66§
El Oro (Mexico)	31,000	216,000†	31,500	210,000†
Esperanza (Mexico)	20,843	577†‡	—	—
Frontino & Bolivia (C'lbia)	2,470	7,562	2,670	7,833
Mexico El Oro (Mexico)	11,000	164,320†	12,200	164,410†
Mining Corp. of Canada	—	128,287*	—	—
Oriental Cons. (Korea)	19,957	108,760†	—	104,650†
Ouro Preto (Brazil)	6,000	2,008‖	6,200	2,11[illegible]
Plymouth Cons. (Calif'rnia)	7,200	9,977	8,350	10,832
St. John del Rey (Brazil)	—	32,000	—	34,000
Santa Gertrudis (Mexico)	36,514	9,779‡	37,588	16,827‡
Sonora (Mexico)	—	—	—	—
Tomboy (Colorado)	16,000	85,000†	15,000	79,030†

† U.S. Dollars. ‡ Profit, gold and silver ‖ Oz. gold.
* Oz. silver. § Oz., 50 oz. platinum and 16 oz. gold.

Production of Gold in India

	1917	1918	1919	1920	1921
	oz.	oz.	oz.	oz.	oz.
January	44,718	41,420	38,184	39,073	34,028
February	42,566	40,787	36 834	38,872	—
March	44,617	41,719	38,317	38,760	—
April	43,726	41,504	38,248	37,307	—
May	42,901	40,889	38,608	38,191	—
June	42,924	41,264	38,359	37,864	—
July	42 273	40,229	38,549	37 129	—
August	42 591	40,496	37,850	37,375	—
September	43,207	40,088	36,813	35,497	—
October	43,041	39,472	37,138	35,023	
November	42,915	36,984	39,628	34,522	—
December	44,883	40,149	42,643	34,919	—
Total	520,362	485,236	461,171	444,532	34,028

Indian Gold Outputs.

	December.		January.	
	Tons Treated	Fine Ounces	Tons Treated	Fine Ounces
Balaghat	3,300	2,564	3,200	2,323
Champion Reef	11,550	5,613	11,293	5,512
Mysore	17,699	12,049	16,515	11,798
North Anantapur	700	1,005	700	920
Nundydroog	8,837	5,222	8,553	5,021
Ooregum	12,900	8,466	12,900	8,464

Base Metal Outputs.

		Nov.	Dec.
Arizona Copper	Short tons copper	1,400	1,325
British Broken Hill	Tons lead conc.	—	2,330
	Tons zinc conc.	—	2,120
	Tons carbonate ore.	—	580
Broken Hill Prop	Tons lead conc.	—	533
	Tons zinc conc.	—	1,207
Burma Corp.	Tons refined lead	2,203	2,445
	Oz. refined silver	278,750	280,210
Fremantle Trading	Long tons lead	310	352
Hampden Cloncurry	Tons copper	505	282
	Oz. gold	324	141
Kafue Copper	Short tons copper	—	—
Mount Lyell	Tons copper	469	357
	Oz silver	14,476	12,279
	Oz. gold	463	352
Mount Morgan	Tons copper	—	587
	Oz. gold	—	9,517
North Broken Hill	Tons lead	—	—
	Oz silver	—	—
Pilbara Copper	Tons ore	97	132
Poderosa	Tons copper ore	250	200
Rhodesian Broken Hill	Tons lead	952	1,323
S'th American Copper	Tons cop. ore ship'd.	—	—
Sulphide Corporation	Tons lead conc.	—	1,373
	Tons zinc conc.	—	1,979
Tanganyika	Long tons copper	—	—
Tolima	Tons silver-lead conc.	55	55
Zinc Corp.	Tons zinc conc.	—	—
	Tons lead conc.	—	—

Imports of Ores, Metals, etc., into United Kingdom.

		Year 1920	Jan., 1921.
Iron Ore	Tons	6,500 911	569 515
Manganese Ore	Tons	452,613	48,312
Copper and Iron Pyrites	Tons	630,564	61,924
Copper Ore, Matte, and Precipitate	Tons	31,164	843
Copper Metal	Tons	104,930	7,508
Tin Concentrate	Tons	41,358	1,379
Tin Metal	Tons	28 749	2,662
Lead, Pig and Sheet	Tons	162,850	12,113
Zinc (Spelter)	Tons	109,367	7,945
Quicksilver	Lb.	2,682,016	2,277
Zinc Oxide	Tons	7 681	389
White Lead	Cwt.	669,491	12,602
Barytes	Cwt.	581 857	31,738
Phosphate	Tons	523 3[illegible]0	92 705
Sulphur	Tons	15,759	—
Borax	Cwt.	8,540	600
Other Boron Compounds	Tons	23,117	1,306
Nitrate of Soda	Cwt.	2,949,530	138,880
Nitrate of Potash	Cwt	184,973	744
Petroleum:			
Crude	Gallons	4,180 128	—
Lamp Oils	Gallons	160,051,046	19,387,468
Motor Spirit	Gallons	207,739,144	32,124,702
Lubricating Oils	Gallons	105,914,877	10 888,366
Gas Oil	Gallon	53,564 775	4,690,163
Fuel Oil	Gallons	347,771,044	28,691,484
Total Petroleum	Gallons	880,207,568	95,782,423

OUTPUTS OF TIN MINING COMPANIES
In Tons of Concentrate

	Oct. Tons	Nov. Tons	Dec Tons
Nigeria:			
Associated Nigerian	20	20	20
Benue	—	—	
Bisichi	16	16	10
Bongwelli	1¾	1½	5¼
Champion (Nigeria)		3	1½
Dua	2½	1	1¼
Ex-Lands	33	35	35
Filani	5½	5	5½
Forum River	10	7½	10½
Gold Coast Consolidated	3	2½	3
Gurum River	15	15	12
Jantar	10	10	20
Jos	[illegible]	24½	26½
Kaduna	13	17½	15½
Kaduna Prospectors	6¾	9	8¼
Kano	5	5¼	
Kuru	12	–	–
Kwall			
Lower Bisichi	8¾	8½	7¾
Lucky Chance	1	1	1
Minna	3	2	1½
Mongu	40	40	50
Naraguta	45	45	42
Naraguta Extended	23	15	17
Nigerian Consolidated	30	22½	23
Ninghi	6	5½	5
N.N. Bauchi	55	55	50
Offin River	7¾	7¼	9¼
Rayfield	35	35	37
Ropp	168	115	126
Rukuba	5½	4	4½
South Bukeru	13	15	15
Sybu	1¼		4½
Tin Fields	8	4	4
Yarde Kerri	5	4	5
Federated Malay States:			
Chenderiang	–	–	103*
Gopeng	72	72	66
Idris Hydraulic	18	19¼	17¾
Ipoh	13¾	13	19½
Kamunting		-	120*
Kinta	32¾	32¾	35¾
Labat	59½	59½	60¾
Malayan Tin	80½	78¾	83½
Pahang	178½	166	166
Rambutan	15	16½	15
Sungei Besi	30	31	30
Tekka	30	30	30
Tekka-Taiping	39	31	27
Tronoh	49½	38	29
Cornwall:			
East Pool	69⅝†	74†	89¾†
Geevor	—	—	–
Grenville	–	—	–
South Crofty	55†	60¾†	62†
Other Countries:			
Aramayo Francke (Bolivia)	180	170	154
Berenguela (Bolivia)	29	27	18
Briseis (Tasmania)	20	23	13
Deebook (Siam)	19½	19½	30½
Leeuwpoort (Transvaal)	—	—	247*
Macready (Swaziland)		—	19*
Mawchi (Burma)		-	-
Porco (Bolivia)	—		—
Renong (Siam)	61½	95½	89¾
Rooiberg Minerals (Transvaal)	50	15	-
Siamese Tin (Siam)	60½	63½	71¾
Tongkah Harbour (Siam)	68	76	73
Zaaiplaats (Transvaal)	28	28	27

* Three months. † Tin and wolfram.

NIGERIAN TIN PRODUCTION
In long tons of concentrate of unspecified content

Note. These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual outputs.

	1915	1916	1917	1918	1919	1920
	Tons	Tons	Tons	Tons	Tons	Tons
January	417	531	667	678	613	547
February	358	528	646	668	623	477
March	418	547	655	707	606	505
April	444	486	555	584	546	467
May	357	536	509	525	483	383
June	373	510	473	492	484	435
July	455	506	479	545	481	484
August	438	498	551	571	616	447
September	442	535	538	520	561	528
October	511	584	578	491	625	628
November	467	679	621	472	536	544
December	533	654	655	518	511	577
Total	5,213	6.594	6 927	6,771	6.685	6,022

PRODUCTION OF TIN IN FEDERATED MALAY STATES.

Estimated at 70% of Concentrate shipped to Smelters.
Long Tons.

	1916	1917	1918	1919	1920
	Tons	Tons	Tons	Tons	Tons
January	4,316	3.558	3,030	3,765	4,265
February	3.372	2,755	3,197	2,734	3,014
March	3,696	3,286	2,609	2,819	2,770
April	3,177	3,251	3,308	2,858	2,606
May	3,729	3,413	3,332	3,407	2,741
June	3,435	3,489	3,070	2,877	2,940
July	3,517	3,253	3,373	3,756	2,824
August	3,732	3,413	3,259	2.956	2.786
September	3,636	3.154	3.157	3.161	2,734
October	3,681	3,436	2,870	3,221	2,837
November	3,635	3,300	3,132	2,972	2,573
December	3,945	3,525	3,022	2,409	2,838
	43,871	39,833	37,370	36.935	34.928

TOTAL SALES OF TIN CONCENTRATE AT REDRUTH TICKETINGS

	Long tons	Value	Average
August 25, 1919	130½	£18,297	£140 4 3
September 8	115½	£16,588	£143 12 6
September 22	135½	£19,557	£144 6 9
October 8	72	£10,867	£150 18 7
October 20	32	£5,093	£159 3 2
November 3	34½	£5,235	£151 15 0
November 17	39	£6,161	£157 19 9
December 1	38	£5,905	£155 8 3
December 15	29	£5,133	£176 10 0
December 31	14¾	£2,884	£195 10 10
Total and Average, 1919	2,858	£366.569	£128 5 0
January 12, 1920	31	£6,243	£201 8 0
January 26	51¾	£10,574	£204 6 10
February 9	37½	£7,880	£210 2 8
February 23	53¾	£12,120	£225 10 0
March 8	18	£4,038	£224 7 7
March 22	44	£8,286	£188 6 8
April 6	44½	£8.367	£188 0 5
April 19	33½	£6,375	£190 6 0
May 3	61½	£11,641	£189 5 9
May 17	44	£6,151	£139 16 0
May 31	10	£1,578	£157 16 0
June 14	24¾	£3,278	£132 9 3
June 28	14½	£1,932	£133 4 10
July 12	43¾	£6,133	£140 4 0
July 26	10½	£1,643	£156 10 0
August 9	10½	£1,664	£158 10 0
August 23	27¼	£4,022	£147 12 0
September 6	19	£2,563	£134 18 6
September 20	10	£1,552	£155 5 0
October 4	9	£1,359	£151 0 7
October 18	39½	£5,225	£132 5 11
November 1	9	£1,329	£147 14 5
November 15	4½	£597	£132 17 6
November 29	8½	£965	£113 12 0
December 13	8½	£981	£115 8 6
December 28	8½	£946	£111 5 10
January 10, 1921	8½	£991	£116 13 0
January 24	7½	£671	£89 11 4

On January 10, Tincroft sold 8½ tons, and on January 24, 7½ tons.

Stocks of Tin.

Reported by A. Strauss & Co. Long Tons.

	Nov. 30	Dec 31	Jan. 31
Straits and Australian Spot	1,944	2,170	2,701
Ditto, Landing and in Transit	620	1,138	40
Other Standard, Spot and Landing	2,743	3,855	4,960
Straits, Afloat	1,955	1,183	345
Australian, Afloat	203	250	264
Banca, in Holland	2,966	3,511	3,341
Ditto, Afloat	1,095	278	356
Billiton, Spot	721	755	755
Billiton, Afloat	295	264	141
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	300	485	60
Total Afloat for United States	3 257	1,734	2,595
Stock in America	2,966	2,856	2,546
Total	19,065	18,479	18,104

Shipments, Imports, Supply, and Consumption of Tin.

Reported by A. Strauss & Co. Long tons.

	Nov.	Dec.	Jan.
Shipments from:			
Straits to U.K.	1,505	915	35
Straits to America	825	825	960
Straits to Continent	300	485	60
Straits to Other Places	199	225	106
Australia to U.K.	350	250	350
U.K. to America	175	150	985
Imports of Bolivian Tin into Europe	2,172	251	341
Supply:			
Straits	2,630	2,225	1,055
Australian	350	250	350
Billiton	482	—	—
Banca	1,154	250	498
Standard	475	1,500	1,290
Total	5,091	4,225	3,193
Consumption:			
U.K. Deliveries	1,607	1,518	1,254
Dutch „	215	366	269
American „	3,420	2,580	1,555
Straits, Banca & Billiton, Continental Ports, etc.	226	347	490
Total	5,468	4,811	3,568

Dividends Declared by Mining Companies.

Date	Company	Par Value of Shares	Amount of Dividend
Jan. 21	Broken Hill Prop.	£1	9d. less tax
Jan. 24	Glynn's Lydenburg	£1.	5% less tax
Jan. 19	Rand Selection Corporation	£1.	3s. 6d. less tax
Jan. 27	Tekka-Taiping	£1.	3d. less tax
Jan. 29	Waihi Gold	£1.	6d. tax paid

PRICES OF CHEMICALS. February 8.

These quotations are not absolute; they vary according to quantities required and contracts running.

		£	s	d
Acetic Acid, 40%	per cwt	1	7	0
„ 80%	„	2	14	0
„ Glacial	„	3	10	0
Alum	per ton	19	0	0
Alumina, Sulphate of	„	16	0	0
Ammonia, Anhydrous	per lb.		2	6
„ 0.880 solution	per ton	46	0	0
„ Carbonate	per lb.			4
„ Chloride of, grey	per ton	54	0	0
„ „ „ pure	per cwt	5	0	0
„ Nitrate of	per ton	50	0	0
„ Phosphate of	„	95	0	0
„ Sulphate of	„	24	0	0
Antimony, Tartar Emetic	per lb.		2	7
„ Sulphide, Golden	„		1	6
Arsenic, White	per ton	50	0	0
Barium Carbonate	„	11	0	0
„ Chlorate	per lb.		1	0
„ Chloride	per ton	21	10	0
„ Sulphate	„	10	0	0
Benzol, 90%	per gal		3	10
Bisulphate of Carbon	per ton	55	0	0
Bleaching Powder, 35% Cl.	„	19	0	0
„ Liquor, 7%	„	7	0	0
Borax	„	38	0	0
Boric Acid, crystals	„	74	0	0
Calcium Chloride	„	10	0	0
Carbolic Acid, crude 60%	per gal.		2	3
„ crystallized, 40%	per lb.			8
China Clay (at Runcorn)	per ton	13 10 0 to 14 10 0		
Citric Acid	per lb.		2	6
Copper, Sulphate of	per ton	36	0	0
Cyanide of Sodium, 100%	per lb.		1	0
Hydrofluoric Acid	„			7½
Iodine	per oz		1	0
Iron, Nitrate of	per ton	10	0	0
„ Sulphate of	„	4	0	0
Lead, Acetate of, white	„	54	0	0
„ Nitrate of	„	50	0	0
„ Oxide of, Litharge	„	45	0	0
„ White	„	51	0	0
Lime, Acetate, brown	„	12	0	0
„ „ grey 80%	„	19	0	0
Magnesite, Calcined	„	22	0	0
Magnesium, Chloride	„	13	0	0
„ Sulphate	„	12	0	0
Methylated Spirit 64° Industrial	per gal.		7	0
Nitric Acid, 80° Tw.	per ton	37	0	0
Oxalic Acid	per lb.		1	2
Phosphoric Acid	per lb.		1	6
Potassium Bichromate	per lb.		1	1
„ Carbonate 85%	per ton	50	0	0
„ Chlorate	per lb.		0	6
„ Chloride 80%	per ton	30	0	0
„ Hydrate (Caustic) 90%	„	55	0	0
„ Nitrate	„	50	0	0
„ Permanganate	per lb.		2	0
„ Prussiate, Yellow	„		1	4
„ „ Red	„		2	0
„ Sulphate, 90%	per ton	35	0	0
Sodium Metal	per lb.		1	3
„ Acetate	per ton	35	0	0
„ Arsenate 45%	„	45	0	0
„ Bicarbonate	„	9	0	0
„ Bichromate	per lb.			10
„ Carbonate (Soda Ash)	per ton	16	0	0
„ „ (Crystals)	„	7	0	0
„ Chlorate	per lb.			4½
„ Hydrate, 76%	per ton	27	0	0
„ Hyposulphite	„	20	0	0
„ Nitrate, 95%	„	22	0	0
„ Phosphate	„	26	0	0
„ Prussiate	per lb.			9
„ Silicate	per ton	11	0	0
„ Sulphate (Salt-cake)	„	9	0	0
„ „ (Glauber's Salts)	„	10	0	0
„ Sulphide	„	30	0	0
„ Sulphite	„	15	0	0
Sulphur, Roll	„	15	0	0
„ Flowers	„	15	0	0
Sulphuric Acid, Fuming, 65°	„	24	0	0
„ „ free from Arsenic, 144°	„	6	5	0
Superphosphate of Lime, 30%	„	8	10	0
Tartaric Acid	per lb.		2	0
Turpentine	per cwt.	4	10	0
Tin Crystals	per lb.		1	7
Titanous Chloride	„		1	0
Zinc Chloride	per ton	27	0	0
Zinc Sulphate	„	20	0	0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS:	Feb. 6, 1920 £ s. d.	Feb. 7, 1921 £ s. d.
RAND		
Brakpan	4 5 0	2 17 6
Central Mining (£8)	12 5 0	6 10 0
City & Suburban (£4)	9 6	6 9
City Deep	3 17 6	2 3 9
Consolidated Gold Fields	2 7 6	17 6
Consolidated Langlaagte	1 10 0	15 9
Consolidated Main Reef	17 0	12 3
Consolidated Mines Selection (10s.)	1 14 6	15 0
Crown Mines (10s.)	4 7 6	2 5 0
Daggafontein	1 2 3	7 6
Durban Roodepoort Deep	10 0	2 6
East Rand Proprietary	14 6	5 6
Ferreira Deep	13 6	8 3
Geduld	3 2 6	2 5 0
Geldenhuis Deep	16 6	8 0
Gov't Gold Mining Areas	5 8 9	3 15 0
Heriot	12 6	9 0
Johannesburg Consolidated	1 18 0	1 2 6
Jupiter	7 9	2 0
Kleinfontein	18 0	7 0
Knight Central	7 6	4 6
Knights Deep	13 3	10 6
Langlaagte Estate	1 3 6	11 6
Meyer & Charlton	5 15 0	4 10 0
Modderfontein (10s.)	4 17 6	3 5 0
Modderfontein B (5s.)	9 2 6	1 10 0
Modderfontein Deep (5s.)	3 1 3	2 1 3
Modderfontein East	1 11 3	17 6
New State Areas	1 12 6	1 2 6
Nourse	17 3	7 9
Rand Mines (5s.)	4 12 6	2 5 0
Rand Selection Corporation	5 11 3	2 12 6
Randfontein Central	1 2 9	9 3
Robinson (£5)	15 6	8 9
Robinson Deep A (1s.)	1 10 0	10 0
Rose Deep	1 8 9	16 0
Simmer & Jack	7 3	3 0
Simmer Deep	3 6	—
Springs	3 2 6	1 12 6
Sub Nigel	1 2 6	11 3
Union Corporation (12s. 6d.)	1 5 6	16 0
Van Ryn	1 3 9	11 3
Van Ryn Deep	5 17 6	3 10 0
Village Deep	1 0 3	8 3
Village Main Reef	10 6	9 6
West Springs	1 6 3	15 0
Witwatersrand (Knight's)	1 5 0	13 9
Witwatersrand Deep	13 3	7 6
Wolhuter	6 3	4 0
OTHER TRANSVAAL GOLD MINES		
Glynn's Lydenburg	17 6	8 9
Transvaal Gold Mining Estates	17 6	8 9
DIAMONDS IN SOUTH AFRICA:		
De Beers Deferred (£2 10s.)	31 10 0	11 5 0
Jagersfontein	7 0 0	2 8 9
Premier Deferred (2s. 6d.)	12 5 0	5 0 0
RHODESIA:		
Cam & Motor	10 6	5 6
Chartered British South Africa	1 2 3	12 3
Falcon	16 0	9 6
Gaika	16 6	9 6
Globe & Phœnix (5s.)	16 0	17 6
Lonely Reef	3 11 3	2 7 6
Rezende	3 12 6	2 15 0
Shamva	2 5 0	1 7 6
Willoughby's (10s.)	7 3	5 3
WEST AFRICA		
Abbontiakoon (10s.)	6 0	2 6
Abosso	15 6	8 6
Ashanti (4s.)	1 4 9	13 0
Prestea Block A	5 0	1 6
Taquah	1 [illegible] 0	8 0
WEST AUSTRALIA:		
Associated Gold Mines	[illegible]	2 6
Associated Northern Blocks	4 [illegible]	2 6
Bullfinch	[illegible]	1 6
Golden Horse-Shoe (£5)	1 7 6	12 6
Great Boulder Proprietary (2s.)	10 6	6 0
Great Fingall (10s).	1 9	1 6
Hampton Properties	1 10 [illegible]	8 9
Ivanhoe (£5)	2 [illegible]	1 0 0
Kalgurli	1 [illegible]	8 9
Lake View Investment (10s.)	1 2 0	10 0
Sons of Gwalia	10 [illegible]	3 9
South Kalgurli (10s.)	6	5 6

GOLD, SILVER, cont.	Feb. 6, 1920 £ s. d.	Feb. 7, 1921 £ s. d.
OTHERS IN AUSTRALASIA		
Blackwater, New Zealand	8 9	8 9
Consolidated G.F. of New Zealand	3 9	3 9
Mount Boppy, N.S.W. (10s.)	6 0	2 6
Progress, New Zealand	1 9	1 3
Talisman, New Zealand	8 9	6 6
Waihi, New Zealand	2 7 6	1 5 0
Waihi Grand Junction, New Z'land	12 6	8 9
AMERICA		
Buena Tierra, Mexico	16 3	5 0
Camp Bird, Colorado	1 3 3	5 6
El Oro, Mexico	16 3	10 6
Esperanza, Mexico	16 6	1 2 6
Frontino & Bolivia, Colombia	11 3	8 9
Le Roi No. 2 (£5), British Columbia	6 6	5 0
Mexico Mines of El Oro, Mexico	6 17 6	4 15 0
Nechi (Pref. 10s.), Colombia	10 6	7 6
Oroville Dredging, Colombia	1 9 0	1 3 9
Plymouth Consolidated, California	1 3 9	17 6
St. John del Rey, Brazil	18 6	15 0
Santa Gertrudis, Mexico	1 18 0	7 0
Tomboy, Colorado	13 9	6 3
RUSSIA:		
Lena Goldfields	1 5 0	12 6
Orsk Priority	12 6	5 0
INDIA		
Balaghat (10s.)	8 6	7 0
Champion Reef (2s. 6d.)	3 9	2 3
Mysore (10s.)	1 1 3	11 9
North Anantapur	4 3	3 0
Nundydroog (10s.)	15 0	6 0
Ooregum (10s.)	17 9	11 3
COPPER:		
Arizona Copper (5s.), Arizona	2 12 6	1 10 0
Cape Copper (£2), Cape and India	2 2 6	15 0
Esperanza, Spain	5 9	5 0
Hampden Cloncurry, Queensland	17 6	6 3
Mason & Barry, Portugal	2 10 0	1 10 0
Messina (5s.), Transvaal	6 6	4 0
Mount Elliott (£5), Queensland	4 0 0	12 6
Mount Lyell, Tasmania	1 6 6	13 9
Mount Morgan, Queensland	1 5 0	12 6
Mount Oxide, Queensland	8 6	—
Namaqua (£2), Cape Province	1 12 6	1 2 6
Rio Tinto (£5), Spain	47 10 0	26 0 0
Russo-Asiatic Consd., Russia	13 9	7 6
Sissert, Russia	17 6	10 0
Spassky, Russia	1 5 0	10 0
Tanganyika, Congo and Rhodesia	3 0 0	1 5 0
LEAD-ZINC:		
BROKEN HILL:		
Amalgamated Zinc	1 6 0	18 9
British Broken Hill	2 3 9	17 6
Broken Hill Proprietary	3 1 3	2 0 0
Broken Hill Block 10 (£10)	1 7 6	12 6
Broken Hill North	2 13 9	1 7 6
Broken Hill South	2 15 0	1 6 3
Sulphide Corporation (15s.)	1 1 3	12 6
Zinc Corporation (10s.)	1 1 6	10 0
ASIA		
Burma Corporation (10 rupees)	13 10 0	8 0†
Russian Mining	15 0	6 3
RHODESIA:		
Rhodesia Broken Hill (5s.)	18 0	8 3
TIN:		
Aramayo Francke, Bolivia	5 5 0	2 10 0
Bisichi, Nigeria	16 0	6 3
Briseis, Tasmania	5 9	4 6
Dolcoath, Cornwall	8 6	3
East Pool (5s.) Cornwall	18 3	4 0
Ex-Lands Nigeria (2s.), Nigeria	4 0	2 0
Geevor (10s.) Cornwall	1 2 0	3 9
Gopeng, Malay	2 5 0	1 10 0
Ipoh Dredging, Malay	1 2 9	12 6
Kamunting, Malaya	1 18 9	2 10 0
Kinta, Malaya	2 16 3	1 12 6
Malayan Tin Dredging, Malay	2 6 3	1 7 6
Mongu (10s.), Nigeria	1 7 6	12 6
Naraguta, Nigeria	17 6	11 3
N. N. Bauchi, Nigeria (10s.)	8 3	1 6
Pahang Consolidated (5s.), Malay	15 3	6 6
Rayfield, Nigeria	14 6	3 6
Renong Dredging, Siam	2 16 3	1 10 0
Ropp (4s.), Nigeria	14 6	6 6
Siamese Tin, Siam	3 17 6	2 10 0
South Crofty (5s.), Cornwall	18 6	5 6
Tehidy Minerals, Cornwall	1 7 6	10 0
Tekka, Malay	4 16 3	1 0 0
Tekka-Taiping, Malay	1 6 3	1 3 9
Tronoh, Malay	2 12 6	1 5 0

† 10-rupee shares of Indian Co.

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also reviews of new books, and abstracts of the yearly reports of mining companies.

KIRKLAND LAKE GOLD MINING DISTRICT.

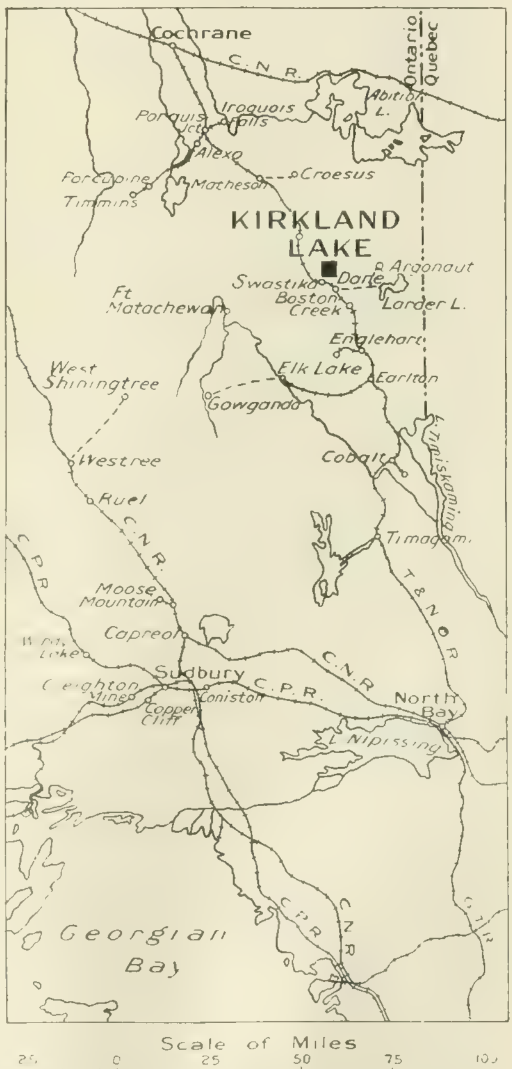
The Ontario Department of Mines has issued a report on the Kirkland Lake gold area by A. G. Burrows and P. E. Hopkins. As this is the fourth most important precious-metal producing district in Ontario, we give herewith lengthy extracts on the general geology and ore deposits. Next month we intend to reproduce the details relating to the individual mines. Reference to the history and development of the district is made in the editorial pages this month.

The Kirkland Lake area is situated a few miles south of the divide between the Hudson Bay and river St Lawrence waters. The lake has an elevation of 1,038 ft. above sea-level and no hill apparently rises more than 100 ft. above that level. There are rock outcrops over most of the area. The small proportion of drift is usually sand, thinly distributed. The mineral deposits are frequently found in the lower parts of the area, since the fractured zones and adjoining altered rocks are more easily eroded than are those that are less fractured and less altered. The porphyry apparently weathers down more easily than the other rocks. The area is part of a large mineralized region that extends roughly from Matachewan in the south-west to Larder Lake and beyond into Quebec province to the east. In places the older gold-bearing rocks are covered by deposits of newer formations, conglomerate, greywacké, and slate of the Cobalt series, which have not been removed by erosion and consequently cover possible gold deposits. The character of the gold deposits varies greatly in different parts of the larger area, but all occurrences are believed to be associated with the acid intrusive rocks of a granite, syenite, and porphyry character that frequently outcrop in various parts of the area.

General Geology.—The compact rocks are Pre-Cambrian, classified according to the following table, the oldest being placed at the bottom and the others in the order of their relative ages.

KEWEENAWAN (?) ...	Quartz diabase and olivine diabase.
POST-TIMISKAMING INTRUSIVES (ALGOMAN ?)	Red and grey felspar-porphyry with subordinate amounts of hornblende-syenite and felsite occurring as dykes and stocks.
	Red hornblende-syenite.
	Black mica lamprophyre grading into or cut by red, hornblende syenite, the latter being felsitic or porphyritic in places.
	(The above three groups of rocks are differentiation facies from the same magma).
	Serpentine.
	Hornblende and biotite granite and gneiss, syenite, granite-porphyry, felspar-porphyry, felsite, pegmatite and hornblendite.
TIMISKAMIAN ...	Schistose conglomerate greywacké and quartzite containing some carbonate schist.
	Rusty carbonate.
KEEWATIN	Pillow lava, altered diabase, green schists, rusty carbonate and iron formation.

The Keewatin, which is the dominant rock in the region, occupies only a small portion along the north and south-east sides of the area. These rocks are chiefly basalt and diabase, volcanic rocks which have flowed out under the sea, with subordinate amounts of iron formation, rusty carbonate, and other rocks. Lying unconformably on these rocks and interfolded with them is a band of Timiskamian sediments which occupies most of the area. These fragmental rocks are two miles in width, and extend to the south-west and to the north-east for several miles. After the deposition of the sediments, extensive folding and metamorphism took place. Later the sediments were cut by a number of intrusives, namely: granite, syenite, serpentine and



MAP OF PART OF ONTARIO, SHOWING POSITION OF KIRKLAND LAKE

related lamprophyre, syenite, and felspar porphyry. The gold deposits are genetically connected with the porphyry. All the rocks, including the ore bodies, have been intruded by diabase dykes of Keweenawan age. These Pre-Cambrian rocks may have been covered by Palæozoic rocks, but no erosion remnants are to be seen at present. The glaciers which passed over the whole region have scraped away any decomposed rock from the surface and carried it southward, leaving the rocks and mineral deposits exposed as we find them. In places the rocks are still covered with a thin mantle of glacial sand and gravel.

Origin and Age of the Gold Deposits. — All the gold deposits of northern Ontario are in the Pre-Cambrian, in rocks which, with few exceptions, are older than the Cobalt series. After the folding of the Timiskaming series and before the deposition of the Cobalt series, there was a period of igneous activity during which basic and acid rocks, including lamprophyre, porphyry, syenite, and granite, were intruded into the older rocks. The probable genetic relationship of the gold deposits of Porcupine to granite intrusions has been noted in a report on that area. There are a number of gold-bearing veins at Kirkland Lake associated with felspar-porphyry and syenite, suggestive of a relationship between the intrusives and the veins. There are areas of granite and syenite within a short distance of the gold deposits. An examination of a number of specimens from these plutonic areas shows that these rocks contain albite, usually as phenocrysts, similar to the felspar-porphyry. It is quite likely that the granite, syenite, and felspar-porphyry belong to the same period of intrusion and are different facies of a magma which underlay or underlies a large part of the area. The syenite and granite have been exposed by deep erosion.

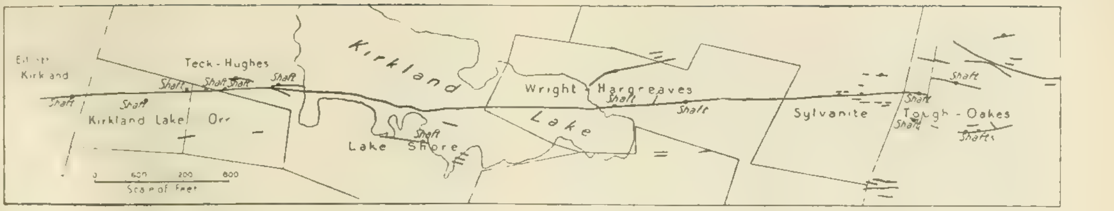
While the gold-bearing veins were formed subsequent to the intrusion of the porphyry, it is likely that they are genetically connected with the intrusive rock which occurs as dykes and boss-like masses. The cooling of the intrusive was apparently accompanied by shrinkage, faulting, and displacement in the porphyry itself and in the adjacent rocks. The gold-bearing silicious solutions that deposited their burdens in the fissures and other fractures in all probability represented the end product of the intrusion of the acid rocks that have been mentioned.

Lindgren, in his classification of mineral deposits, places the gold-quartz veins of Ontario in the division of "veins and replacement deposits formed at high temperature and pressure and in genetic connection with intrusive rocks." He says: "These veins are clearly related to those of the southern Appalachian states, but, on the other hand, they present some remarkable analogies with those of California." These veins were formed at considerable depth and have been exposed by extensive erosion, but it is probable that they were not formed at as high temperatures as the veins at Porcupine, in which tourmaline and pyrrhotite frequently occur. The minerals tourmaline, pyroxene, garnet, amphibole, and biotite, characteristic of deposits formed at high temperatures, have not been recognized by the writers in the Kirkland Lake area. Albite, chlorite, sericite, and carbonates are present in the deposits as alteration products. The veins at Kirkland Lake in their mineral constituents greatly resemble those of the Sierra Nevada, California, which are described by Lindgren. In these latter veins tellurides like altaite, hessite, calaverite, petzite, and melonite are frequently associated with native gold. In a comparison of the Cripple Creek and Kalgoorlie gold deposits, Lindgren has shown that telluride of gold may be deposited in large quantities both near the surface (as at Cripple Creek), and at a depth of many thousands of feet below it (as at Kalgoorlie). Telluride of gold is not so abundant in the Kirkland Lake deposits as telluride of lead, but probably occurs in greater quantity than has been suspected owing to the difficulty of identifying the telluride in fine grains when accompanied by native gold. As stated above, the mineral associations at Kirkland Lake are not typically those of high temperature deposits. Magnetite has been found in gold-bearing veins at the Argonaut mine, a few miles east of Kirkland Lake, and specularite has been reported in veins from the Tough-Oakes mine. The Kirkland Lake deposits have probably been formed at considerable depth, like the Kalgoorlie deposits, but not at such high temperatures, while the mineral association is somewhat similar in that native gold accompanies the tellurides.

Distribution of Ore Deposits. — Exploration in the Kirkland Lake area has indicated three principal zones of mineralization. The main or central zone is that which runs north-easterly and south-westerly along the southern expansion of Kirkland Lake and along which a group of mines is being developed over a distance of 2¼ miles. The principal mines of the area, Tough Oakes, Burnside, Sylvanite, Wright-Hargreaves, Lake Shore, Teck Hughes, Orr, Kirkland Lake, and also several prospects are situated along this zone. A southerly zone lies about ¾ mile to the south with a similar strike, and along it are the Ontario-Kirkland, Hunton, Honer, and Canadian-Kirkland, on which considerable work has already been done. A northerly zone, known as the Goodfish Lake gold area, lies about two miles north of the central zone, where a number of properties, including the Costello, La Belle Kirkland, and Fidelity, are located.

Kirkland Lake Mineral Zone. — The greatest amount of work has been done on the central zone, where a number of gold bearing veins have been discovered extending over 2¼ miles in length and a width of ½ mile. In this zone operations have shown a major fracturing along which the principal properties are located. It is believed that, after the intrusion of the porphyry and syenite, faulting took place in lines roughly parallel with the long axis of the intrusions, accompanied by fracturing and crushing of the porphyry and other rocks with the formation of the veins or lodes along these fracture planes. The principal or major fracturing can be traced across a number of properties where ore-shoots are being developed at widely separated points, but evidently along one system of fracturing. This fracturing has crossed all the different rocks in this zone, including felspar-porphyry, syenite, lamprophyre, and conglomerate. No. 1 vein at the Kirkland Lake mine, No. 2 vein of the Orr, No. 3 vein of the Teck-Hughes, No. 2 vein at the Lake Shore, and No. 2 vein at the Wright-Hargreaves are being developed along the major fracturing. In addition there are branch veins and other fractures roughly parallel, on which development has been done on a number of properties; examples are No. 1 vein at the Lake Shore, Nos. 1 and 5 veins at the Teck-Hughes, and No. 1 vein at the Wright-Hargreaves.

The fault planes along which the ore deposits have been formed dip to the south, usually at a high inclination, 80° to 85°, although locally there are rolls in the fault planes that are steeper or flatter than the average dip. A fracture zone will contain several fault planes, which often form the boundaries of ore, and at several mines development has been carried on with regard to two prominent fault planes called foot-wall and hanging-wall planes. These planes are from a few feet to 40 ft. or more apart, the ore sometimes occurring over this whole width, or, as is more frequent, near one or the



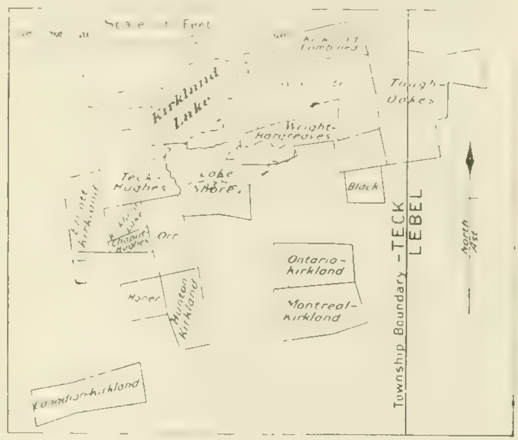
MAP SHOWING PRINCIPAL WORKINGS AND LODES AT KIRKLAND LAKE.

other wall, depending on subsidiary slip or fault planes. The ore will also at times extend beyond the recognizable fault planes or so-called vein boundaries.

The faulting and fracturing of the rock has permitted the circulation of mineral-bearing solutions with accompanying vapours, which have partly filled any open fissures and partly replaced the country rock in the fracture zone. The amount of vein quartz in the ore deposits is relatively small as compared with the mineralized porphyry or other rock through which the fractures have extended. In addition to irregular masses of quartz several feet in width that occur along the veins, there are numbers of narrow irregular quartz veins a few inches in width penetrating the porphyry or other rock, together with mineralized or replaced rock, which make up the ore-body. In consequence of the irregular distribution of quartz in the veins the working faces along drifts on the veins vary greatly in appearance, sometimes showing considerable quartz and at other times almost entirely mineralized porphyry or other rock with minute veinlets of quartz intersecting it.

The mineralization of the veins has extended over a long period, since there has been repeated fracturing along the mineralized zone. The primary quartz is greatly brecciated, and fragments of quartz and porphyry have been displaced along the fault planes. Movement along the walls in the ore-bodies is evidenced by grooving and slickensided surfaces in the direction of movement. Information as to the extent of horizontal displacement may be obtained at the Teck-Hughes mines, where a north and south dyke of diabase 60 ft. in width has been faulted a distance of 150 ft. along No. 3 vein, the part of the dyke to the north of the fault planes being to the west. Several large blocks of diabase occur in the fracture zone together with masses of crushed porphyry or syenite thrust along the fault planes. Mineralization even later than this extensive movement is indicated by the presence of gold values along slip planes in fragments of diabase in the fault zone. The unaltered diabase itself does not carry gold values.

Mineralization of Porphyry and Syenite.—There has been an extensive mineralization of porphyry and syenite in parts of the area that extend through the southerly part of Kirkland Lake. This is apart from that mineralization which occurs with the commercial ore-bodies. The long cross-cuts connecting Nos. 1 and 2 veins on the 200 ft. and 400 ft. levels at the Lake Shore mine are through these rocks. The assay plans show numerous assays of gold from traces up to 40 cents with occasional higher assays of rock in the cross-cuts. This rock when examined closely is seen to carry minute veinlets of quartz with disseminated iron pyrites, which would account for the frequent gold values. Similar low values are shown in cross-cuts at other properties away from the veins, indicating a general mineralization of much of these intrusives away from the recognized veins. This mineralization is probably dependent on the faulting and fracturing previously referred to along the central zone, and not, as



PLAN OF MINING PROPERTIES AT KIRKLAND LAKE.

might at first be supposed, due to a gold distribution at the time of the crystallization of the intrusive rock.

Character of Gold Deposits.—The early development of the Kirkland Lake area was chiefly at the Tough-Oakes mine, where a number of narrow gold-bearing veins were discovered. The most important was No. 2, which, at the surface, carried extremely high-grade ore over a width of 2 to 6 in in the conglomerate, the vein fissure being largely filled with quartz. Development proved that the vein ran from the conglomerate into the porphyry on the surface and at depth, and by far the greater part of the gold extraction has come from the ore-shoot in the porphyry. While the high-grade quartz vein in the conglomerate carried most of the values with mill ore in the wall-rock affording a narrow compact ore deposit, when it entered the porphyry the quartz occurred usually in narrower veinlets spread across a greater width with much fracturing of the porphyry along the vein. Consequently most of the ore in the porphyry is fractured porphyry with numerous slip planes, along which quartz, calcite, and ore-bearing minerals have been deposited, affording a greater width of ore than in the conglomerate. The stopes on the vein average about 5 ft. in width. Development on other veins on the property also indicated that they contained narrow ore-bodies either in the porphyry or greywacké and conglomerate

The early exploration farther west along the mineralized zone did not meet with such satisfactory results, the veins in the conglomerate and porphyry along the surface not showing such high-grade ore as occurred at the Tough-Oakes, with the exception of the north vein at the Wright-Hargreaves, which produced a small amount of high-grade ore when it was operated for a short time in 1913.

The main fracture zone, or main vein, which for most of its length is in low ground or under the bed of Kirkland Lake, was difficult to prospect, and only after

several years of work has it been proved to be the locus of the principal ore deposition. Much of the previous work was done on parallel or subsidiary and narrower veins. In the main fracture the ore deposits have been found to be wider than had been expected, reaching in places 40 ft. in width, but as a general rule running from about 5 ft. to 15 ft. in width.

Strictly speaking the ore-bearing deposits should be called lodes or composite veins formed under strong compressive forces, with the solutions following openings along fracture planes in an irregular manner and partly replacing the country rock adjacent to the fractured planes. The stringers and masses of quartz intermingled with the fractured porphyry or other rock generally lie in the direction of the vein or lode, but are often connected by transverse stringers. The replacement character of the ore is frequently recognized by masses of quartz spotted with remnants of red porphyry; this ore has a faint reddish colour due to the included porphyry. In other cases masses of ore are bright red porphyry or syenite with very thin seams of quartz that are hardly recognizable. The lenses of quartz are sometimes several feet wide in portions of an ore deposit and contain much visible gold together with tellurides, pyrite, copper pyrites, molybdenite, etc. Some of the ore shows very little vein quartz, and specimens of altered red syenite from the Lake Shore mine have been found to contain grains of gold in the secondary minerals, calcite, and sericite intermingled with the original felspars of the rock. Mining operations at the Kirkland Lake mine, October, 1920, have indicated promising ore at a depth of 900 ft. where the same general mineralization has been encountered.

Minerals in Kirkland Lake Veins.—The oldest mineral in the veins, apart from the rock-forming minerals, is a coarsely crystalline quartz. Usually this quartz has been broken up and other minerals deposited in the fracture planes. Of these there is quartz, often of a somewhat darker colour than that first deposited. Carbonates of various composition are present in the veins. A pink carbonate proved on analysis to be calcite with 5·34% of magnesium carbonate; a grey variety is ankerite. There have been different periods of fracturing. Some of the quartz is later than the carbonates. Where there have been inclusions of country rock in the vein and replacement, some sericite has been developed. Chlorite also occurs as a vein material. Iron pyrites is the most abundant of the sulphides, being found both in the wall-rock and in the veins, usually in well crystallized forms. Some of the pyrite in the vein is in fine grains. Copper pyrites occurs to some extent, generally where the vein is gold-bearing. Galena and zinc blende occur in very small quantity. The latter material has been observed in small incrustation veinlets, which are later than the ore. Molybdenite has been deposited abundantly in fractures, usually as a thin film. Graphite has been recognized in some of the ore. This mineral, when in thin films, is difficult to distinguish from molybdenite. Crushed iron pyrites along slip planes has also produced a bright blackish deposit that resembles molybdenite or graphite. Gold-bearing solutions have circulated along these planes, and the veins have been enriched by the deposition of gold in these later fractures. Later movements have often occurred along these planes, and the gold, altaite, and other tellurides, pyrite, copper pyrites, molybdenite, and graphite deposited along the planes have been crushed and polished or slickensided. In some cases the gold has been deposited after the slickensides have been formed, since veinlets of the metal have been observed on the 200 ft. level of the Tough-Oakes mine cutting across the smooth planes of the molybdenite. One of the latest minerals with white calcite along fault planes is barite of a deep red colour, observed at the Teck-Hughes and Lake Shore mines.

Several tellurides have been recognized in ore from the Kirkland Lake area. The most abundant telluride is altaite (PbTe), telluride of lead, which has been recognized in ore from all the mines in the central zone. This mineral is readily recognized by the well developed cubical cleavage and brilliant cleavage planes. It has a very faint greenish tinge, which aids in recognizing it in fine grains. This mineral is usually accompanied by visible gold and its presence often indicates high-grade portions of the vein. Telluride of gold, calaverite ($AuTe_2$), has only been recognized in ore from No. 3 vein at the Tough-Oakes mine. Specimens from this vein show calaverite in quite coarse grains and readily recognizable. The mineral is of a pale brassy, almost white colour, brittle and quite soft. It resembles pale-coloured iron pyrites, but is much softer. The mineral on assay yielded 40·6% gold. This mineral is probably sparsely distributed in the ore, but if in very fine grains would be difficult to recognize in hand specimens. Black tellurides carrying mercury have been recognized recently in specimens from the Tough-Oakes mine. One of these corresponds to kalgoorlite, a telluride of gold, silver, and mercury. An analysis of selected material by W. K. McNeill gave the following composition: Au 20·40%, Ag 31·1%, Hg 10·2%. Another telluride contains mercury and tellurium with no gold or silver and is coloradoite. These mercury-bearing tellurides were definitely recognized in polished surfaces by means of the microscope and by chemical and blow-pipe tests. A mercury telluride, probably coloradoite, also occurs in specimens of ore from No. 2 vein at the Lake Shore mine. The mineral is here associated with native gold, altaite, pyrite, and copper pyrites. The tellurides, tetradymite (telluride of bismuth), and hessite (telluride of silver), have been reported from No. 2 vein of the Tough-Oakes mine, but have not been recognized by the authors.

Examination of a number of thin sections of ore from the Kirkland Lake area shows that the vein material has been much brecciated. Fragments of porphyry, syenite, conglomerate, or greywacké, depending on the character of the wall-rock, are enclosed in vein materials, which are chiefly quartz with calcite and dolomite. Replacement of the various rocks by quartz is also in evidence. The coarsely crystallized quartz of the first generation is fractured, and the fracture filled with later quartz, calcite, and dolomite. The principal sulphide and telluride minerals occur chiefly with the finer-grained material in the minute fracture planes in the quartz and altered rock. An interlacing meshwork of metallic sulphides and tellurides with native gold is frequently observed. Wherever the tellurides occur, native gold is usually recognized in grains close to the telluride grains. Grains of gold are seen in the tellurides, and again minute veinlets of gold sometimes traverse coarse masses of telluride. The crystallized calcite frequently contains gold that has been deposited along the rhombic cleavage planes. The contact of fragments of porphyry or other rocks with quartz is usually a place for concentration of the sulphides, tellurides, and gold. Replacement of the rock is recognized by a gradual transition to quartz and other later minerals. Native gold has been observed in contact with telluride, molybdenite, pyrite, and copper pyrites. A section of high-grade ore from the Kirkland Lake mine shows quartz in contact with altered syenite. There is a concentration of pyrite and tellurides with gold along the contact of quartz and rock and also in the quartz, which is fractured and carries fine-grained

quartz and calcite in the fracture planes. There is abundant sericite and carbonate in the altered rock. A blackish mineral in very thin films is believed to be molybdenite. A sample of high-grade ore from Kirkland Lake mine, containing 21·42 oz. of gold per ton, has the following partial composition: Fe 1·65%, MoS_2 0·34%, S 0·65%, C 0·09%, Te 0·10%. This analysis shows the presence of both molybdenite and graphite in the ore.

(To be continued).

SULPHUR IN SOUTH AFRICA.

The *South African Journal of Industries* for November contains a report by T. G. Trevor, Inspector of Mines, on the production and consumption of sulphur in South Africa. The demand for sulphur in South Africa is great, both in its elemental form for vine dressing, etc., and as sulphuric acid for the manufacture of explosives, fertilizers, and many other at present smaller chemical industries. The imports in 1917 were: sulphur, 899 tons; pyrites, 18,465 tons; sulphuric acid, 37,435 lb. The prices were approximately £10 per ton for sulphur, £3. 9s. for pyrites, and 4½d. per lb. for sulphuric acid. In 1913, before the war, the quantities were as follow: sulphur, 2,672 tons; pyrites, 22,903 tons; sulphuric acid, 291,976 lb. The following were the approximate values: sulphur £6. 8s per ton, pyrites £2. 13s. per ton, sulphuric acid 4 2d. per lb.

In 1918 it was reported that there were three explosives factories, one chemical, and one fertilizer works in the country, which were producing sulphuric acid for their own needs, producing it for trade when they get the necessary pyrites and convenient railway facilities. Two large by-product works were then starting and more will doubtless follow; these also will need either to buy or to make their own acid. The names and addresses of the above-mentioned works and the essential details about them in August, 1920, are given in the accompanying table. The Cape Explosives Company do not at present accept gold-bearing pyrites. The other companies purchase the gold contents at their current value less certain agreed charges. It will be seen from the table that the present demand for pyrites is 1,650 tons per month, and in fifteen months' time it may be 3,500 tons. It is more than likely that this demand will increase by leaps and bounds, for the enormous quantities of low-grade cheap coal in the country, which contains a high percentage of nitrogen, is already attracting world-wide notice, and, given a cheap source of sulphuric acid, the fertilizer industry is capable of indefinite expansion; other industries also are daily springing up, most of which need the acid. It is therefore necessary to study the question of the possible sources of supply.

Native sulphur occurs in small quantities, probably as a product of the decomposition of pyrites, in the cavities of honeycombed quartz in the mines of Pilgrims Rest. It has also been found occurring in some of the rocks of the coastal belt near Port St. Johns, but so far as is known neither of these occurrences is, or is likely to be, of any commercial importance. From the coastal plain at Walvis Bay a sample of native sulphur, a few pounds in weight, has recently been received by the Geological Survey Department. This appears to be native sulphur mixed with sand. It burns freely, and evidently contains at least 50% of sulphur. It is said to occur from Walvis Bay southward to Conception Bay in surface agglomerations in the same sands that carry the diamonds. The occurrence was brought to the knowledge of the De Beers Company some years ago, but that company did not interest itself in it, considering the quantities to be too small, though its agents estimated that some 90 tons might be collected from the visible deposits. The occurrence, however, has not been scientifically investigated, and, in view of the extraordinary developments which have attended the following of somewhat similar surface occurrences in Texas, it certainly merits closer attention. For the time being, however, it must be admitted that the Union is void of any known deposit that is likely to develop into a profitable sulphur mine.

Up to 1915, when the war began to curtail the supply of foreign sulphur and pyrites, there had never been any demand or inquiry for pyrites in South Africa, with the result that no one had ever sought for it, or recorded its occurrence if found in prospecting for other metals. A lode or deposit of massive pyrites never appears on the surface, except as an outcrop of barren ferruginous gossan. There are many such known to the author in the Transvaal, and there must be many more, but, as they show nothing in the pan to the prospector, and as pyrites of itself was formerly of no value, they have never been opened, and, with one exception, no massive pyrites is yet known in the Union. The exception mentioned is the Areachap copper mine, situated some

PRODUCERS OF SULPHURIC ACID IN SOUTH AFRICA.

	Process used	Kilns adapted for	Minimum Sulphur content acceptable	Maximum Arsenic content acceptable	Quantity of Pyrites used per Month	Maximum Quantity of Pyrites needed per Month	Quantity of Sulphur used per Month	Maximum Quantity of Sulphur needed per Month
			%	%	Tons	Tons	Tons	Tons
B.S.A. Explosives Works, Modderfontein	Chamber and Contact	Sulphur and Concentrates	43–45	0·5	200–220	200–220	130	130
Natal Ammonium Co., Mt Ngwibi, Natal	Chamber	Concentrates	35	1·0	250–300	300	None	None
New Transvaal Chemical Company, Delmore	Chamber	Sulphur and Concentrates	38	0·1	200	300–500	Varying	Varying
Cape Explosives Works, Somerset West, Cape Province	Contact (Proposed to erect Chamber)	Sulphur and Concentrates	45	0·25	None at present	In 8 months, 500 In 15 months 1,500	200	200
Kynochs Ltd., Umbogintwini, Natal	Contact and Chamber	Lump and Concentrates	35	0·1	1,000	1,000	None	None

28 miles from Upington and 10 miles from the railway. This mine was discovered in 1906 and closed down in 1909. It was reopened on the advent of the railway to the neighbourhood in 1916, but again closed down in 1917. In the first period an attempt was made to run the Areachap solely as a copper mine. In the second period attempts were made to establish a trade in pyrites. Some few hundreds of tons were supplied to the explosives factories, and the ore was found to be entirely suitable for burning, but the expenses were so great that there was no profit in it for the mine. If a railway siding were constructed to the mine, which could be done at an estimated cost of £17,000, and the mine were properly developed and equipped, it seems well within the bounds of possibility that the mine would prove to be the permanent and reliable source of pyrites which is needed; but in the meantime the railway waits on the development of the mine, and the mine waits on the construction of the railway.

The average of assays of Areachap ore delivered to Messrs. Kynoch in 1916 was sulphur 38·9%, and arsenic 0·11%, but in many other assays the arsenic appears as nil. On the surface the outcrop of this lode shows as a ferruginous gossan of great extent, being 50 ft. wide and 1,450 ft. in length. Small masses of native copper and some nodules and bunches of copper sulphide occurred in this gossan. A main shaft was sunk to the depth of 295 ft. and several other shafts to lesser depths, but no iron pyrites was found above the 200 ft. level. Down to that level the ore was completely oxidized to gossan. The iron pyrites begins at 200 ft., and at 223 ft. the lode, inclusive of some horses, is said to be 50 ft. wide and to consist of massive pyrites assaying 39% sulphur. Such a mass of pyrites would, under ordinary circumstances, be of great value, but, situated as it is—10 miles from the railway and more from fresh water and many hundreds of miles from anywhere where the product can be economically used—it has so many difficulties to overcome that the price of the pyrites at the point of use can never be as low as is desirable in competition with the imported article.

Though the Union is, for the present at all events, void of satisfactory workable deposits of massive pyrites, yet disseminated pyrites is common throughout all the older formations, and plentiful in all the gold-bearing rocks and in most of the coal mines. It is from these sources that the present local supply of pyrites for the South African factories is being derived, and this source of supply seems to be capable of great expansion to the advantage of the gold and coal mines.

The coal in the working coal mines of the Transvaal and Natal contains an average of about 1·5% sulphur in the form of pyrites; this equals say 3% pyrites. For the ordinary coal trade it is not necessary to eliminate this, but for making metallurgical coke it is imperative that the coal should have as low a sulphur content as possible. One large and several small coking plants are now being erected, and the demand for coke by the Pretoria iron mines alone, on the estimated output of 300 tons of iron per day, will be some 350 tons per day—say 10,500 tons per month. This coke will take for its formation—including the loss in sorting and washing—probably 18,000 tons of coal. Over and above the demands of the Pretoria iron mines it is likely that there will be an almost equal general demand, and it will not be an exaggeration to say that in the course of the next year or two 30,000 tons of coal per month will be coked in the country. Allowing that half the pyrites, or say 1·5%, is recoverable in the washing plants, this will yield a supply of some 450 tons of pyrites per month, and, as this will be a by-product, its cost to the acid factories should be well within the economic limits.

All the gold ores in the country, with the exception of the free-milling ores in the oxidized outcrops, are charged with disseminated pyrites, and this pyrites invariably carries a considerable proportion of the gold. In the banket reefs of the Rand, this amount is commonly about 3%, and about 2·5% could be reckoned on in the tailing dumps. This pyrites also carries a considerable value in gold, though it is a mistake to consider that all the gold lost in the tailings is contained in it. The author is informed that some years ago Professor Stanley investigated the question of concentrating these dumps and extracting the sulphur and gold from the concentrates, but came to the definite conclusion that in so far as the Main Reef dumps went it was not a payable proposition. On the Black Reef, however, near where the outcrop of the reef is crossed by the Natal Spruit, there were several old mine dumps which contained upwards of 20% sulphides, and in the Klerksdorp district the Machavie mine gave an ore carrying an equal amount. For the last ten years and more this source of supply has been drawn upon by the New Transvaal Chemical Company for their sulphuric acid works, and latterly some has also been supplied to Kynochs and the Natal Ammonium Company. Unfortunately the dumps are now worked out and the supply from the Machavie mine became too costly, and that mine has had to close down. About 1906 the so-called Sandstone Reef at the Sabie was discovered. This is an interbedded quartz reef in the sandstone lying between the Black Reef and the dolomites. Usually it is up to 3 ft. in width and carries up to 7 dwt. gold and 25% pyritic material. A good many small mines have since then been worked on this reef.

In 1916 the surviving mines, which had been worked with some small degree of success by their owner-managers, became aware of the possible value of the pyrites in their tailings, and negotiations were entered into with the explosives companies. A good deal of difficulty attended these negotiations; the owners did not wish to go to the expense of concentrating plants unless the explosives companies would contract to buy the concentrates; the explosives companies did not wish to alter their plants to burn fines or to accept a contract unless they were first satisfied that the other parties were really in a position to keep their contract over a period of years. This difficulty has now been overcome, and the following mines are turning out a regular supply, much to their profit, and other mines are preparing to do so too: Ceylon-Lydenburg, 67 tons pyrites per month; Buchanan Syndicate, 156 tons pyrites; Jollie Bright, 105 tons pyrites. These figures are for July, 1920. The terms on which the concentrates are purchased are approximately as follow: The purchasers pay 30s. per short ton for concentrates carrying 45% sulphur f.o.r. Sabie; the gold contents to be extracted by the purchaser and to be the property of the sellers, 6s. per ton being deducted for extraction charges. All by-products which may be discovered in the pyrites to be shared equally by both parties. As these concentrates usually carry over 10 dwt. of gold, and in many cases double that quantity, it is obvious that this demand for pyrites has been very much to the advantage of the mine-owners, who are receiving 64s. per ton or more for concentrates which were formerly lost, merely at the additional cost of concentration, which must equal a value of about 10s. to 12s. per ton on the rock crushed, and this advantage has enabled them to continue working profitably when otherwise the increased cost of stores, etc., in the past two years would probably have led to some of them at least clos-

ing down. It is probable, however, that the explosives companies, though their position has been greatly relieved by the local supply of pyritic sulphur, are not in such a satisfactory state as they were before the war, and that for a long time a struggle will go on between the consumers and the producers before a stable price is arrived at. The Rietfontein mine, though not on the Sandstone Reef, produces, say, 5% concentrates carrying up to 3 oz. of gold to the ton. This mine formerly had great difficulties with its extraction, but these have now been overcome by selling the concentrates on terms similar to the above.

In 1919 these mines were supplying about 400 tons of pyrites per month. This supply can, and probably will be increased to about 1,000 tons, but even then the present demand, which is not less than 1,650 tons, will not be satisfied, and the question must be asked how can this deficit be made up and provision for the increased demand which is sure to arise be made Failing the discovery of massive pyrites it is possible that the demand may be met by the mines of the Barberton district. Practically all the mines of that district are pyritic, and there are many reefs and deposits which have never been worked because they were so pyritic that there was little chance of their paying as free-milling propositions. The Sheba mine of late years has been entirely a concentration proposition, and about 300 tons of concentrates were produced monthly, but the local treatment was not profitable. The mine has now reopened, and is, or shortly will be, again in a position to produce these concentrates, and if these can be sold somewhat on the same terms as those from the Sabie the question of the payability of the mine will be largely solved. Unfortunately, however, these concentrates contain a considerable percentage of arsenic, which is almost absent in those from the Sabie, which contain only 0·01 to 0·14%, and the consuming companies are loth to use it, as so far they have been able to either import or obtain locally pyrites low in arsenic. For the contact process it is true that arsenic is very undesirable, as even very small quantities have extremely detrimental results, and must be eliminated during the process; but for the chamber process there are quite sufficiently satisfactory dearsenicating processes which are not particularly costly, and it appears that when once pyrites containing 1% or so of arsenic is accepted, a supply quite equal to the demand might be obtained from the Barberton district. Unfortunately the claims in this district are all in the hands of small men, who cannot afford to develop on pyrites unless they can first get a firm offer for their product. The consumers are not likely to give this, and in order to give it go to the preliminary expense of adding a dearsenicating process to their plant, unless they are certain of a fixed and reliable supply. The properties at Barberton, which the author has in mind as possible producers of auriferous pyrites, are as follow: (1) Mount Morgan mine, Moodies; concentrates 15% to 29%, gold in original ore believed to be not less than 8 dwt. (2) North Star mine; concentrates 20% to 25%, gold in original ore believed to be not less than 5 dwt. (3) French Bobs mine; concentrates 25% to 30%, gold in original ore believed to be not less than 4 dwt., much arsenic, etc. (4) Golden Hill claims; concentrates 20%, gold in original ore believed to be not less than 5 dwt. (5) Eagles Nest mine; portion carries 20% concentrates, gold in original ore believed to be not less than 5 dwt. But, among the old and abandoned claims, which were abandoned because there was too little gold and too much pyrites, and of which no record has been kept, there must be many others, and the subject is one which he believes would thoroughly repay investigation *in loco* by any of the prospective consumers. It will not be sufficient for them merely to express their desire for such concentrates and to wait until sellers come forward with them, for mining in Barberton is at such a low ebb at present that there are not enough well-to-do miners and prospectors left to take advantage of such an offer. It will be necessary to send a competent engineer to the district to investigate every deposit that can be heard of and to make arrangements for having such proved as seem most suitable. It will be impossible to embark on any scheme of development otherwise.

REPAIRING LENS COLLIERIES BY CEMENTATION.

In December, H. Standish Ball read a paper before the South Wales Institute of Engineers on the Francois cementation process as applied to mining. In the course of this paper the author described the repairing of shafts in the Lens district in northern France after the retirement of the German armies.

As a result of the British victory on the Vimy Ridge on April 9, 1917, a large number of the collieries in the neighbourhood of Lens were recaptured from the Germans, and a military engineer was immediately instructed to carry out an investigation and ascertain whether there was an underground communication with Lens, that town being still in hostile hands. Fosse 11 was the first pit examined within a few days after the German retirement. On reaching the heap of débris representing the surface plant a roaring sound was heard, apparently proceeding from the depths of the shaft. A small party was formed, and after some difficulty succeeded in descending the shaft for a certain distance. The noise was found to be caused by water pouring through a cavity in the tubbing some sixteen feet square. Through this cavity the water was pouring at the rate of many thousand gallons a minute. The break in the tubbing occurred about sixty yards from the surface, and some distance below the permanent chalk water-level. Traces of German handiwork were apparent, being represented by a kibble used by their demolition party, electric leads, &c. So rapidly were the workings of the mine flooded that, in spite of the shaft being some 340 yards deep, the water rose to the chalk water-level within the space of a few days. On measuring the water-level in several other pits the rise was found to be constant, proving that all the eighteen pits of the Concession de Lens were flooded; it was therefore thought probable that other shafts had been treated in a similar manner to the one mentioned. This was found to be the case, and negotiations were immediately entered into by the French Government with various English firms to supply pumping machinery for the unwatering of these pits when once the breaks had been sealed off.

Soon after the conclusion of hostilities Monsieur François was entrusted with the work of repairing several of the shafts. By means of suitably placed bore-holes and injections of cement under high pressure the water flowing into these shafts was sealed off in a comparatively short time, and the ultimate recovery of the coal greatly expedited. The procedure adopted in the cementation of each pit differs little in detail; it is therefore only proposed to deal with pit No. 11. When the pit was originally sunk, a very large horizontal fissure was encountered at a depth of 63 yards, a certain amount of difficulty being experienced in dealing with the great amount of water. This fact

was taken advantage of by the Germans, for a charge was exploded in the shaft at the exact depth of the fissure, causing holes 16 ft. by 22 ft. and 19 ft. by 13 ft. to be blown in the sides. The resulting rush of water has been already mentioned, and it was this break in the tubbing and consequent flooding of the mine that had to be dealt with by cementation.

Fig. 1 shows a section of the shaft, giving particulars of the shaft lining, ground, and position where the tubbing was blown out by explosion, the lower charge having been exploded previously without any very serious result. Fig. 2 is a plan of the cementation holes, each hole having been bored vertically downward to a depth of 125 yards, to ensure its reaching below the bottom of the water-bearing measures. The diameter

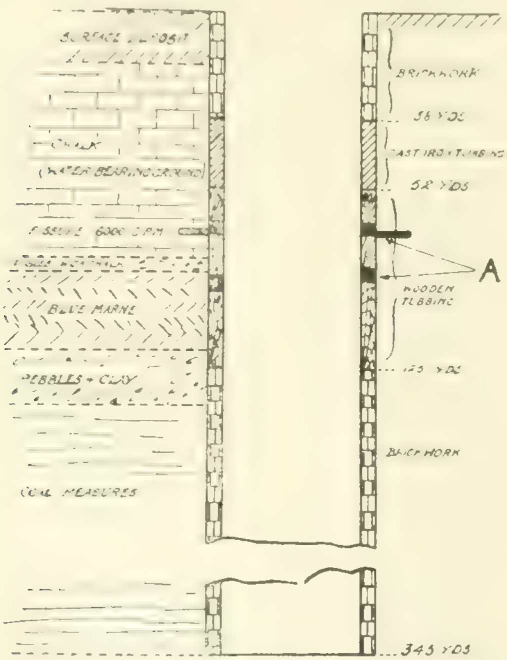


FIG. 1. SECTION OF A SHAFT, SHOWING TUBBING DESTROYED BY EXPLOSION.

High Water Mark of Permanent Chalk Water Level 45 yds. Low Water Mark 52 yds.; Tubbing broken by Explosion of Two 220 lb. charges shown at A.

of the shaft was 16 ft., that of the outside circle of holes 84 ft., and the inside circle 67 ft. The outside circle was injected and finished before the inside one was commenced. The holes were treated in pairs, being situated on opposite sides of the shaft, the one being bored while the other was being injected. An average of fourteen injections was found necessary in each hole, the injection commencing at a depth of 39 yards and being repeated about every 5 yards down, whenever water was being made in the hole. A total of 340 tons of cement was used for the outer holes and 101 tons for the inner ones. When injecting, the pressure was not allowed to rise above 200 lb. per square inch, this being found ample for the type of ground under treatment. One foreman and eleven men were employed on each shift, the total time taken for the completion of the work being just under three months. The following particulars of cement injected are interesting, as on referring to Fig. 2 they show clearly the amount of cement taken up by the fissure:

Hole	Cement injected Tons.	Hole	Cement injected, Tons.	Hole	Cement injected Tons.
1	56	9	30	17	14½
2	51	10	34	18	8
3	19	11	8	19	5
4	19½	12	17½	20	10
5	18	13	6½	21	8
6	41	14	4	22	2½
7	40	15	8	23	½
8	33	16	20	24	1½

On the water-level in the pit falling sufficiently to allow of the tubbing break being examined it was found that the flow of water had been completely sealed off, and in the place of the 6,000 gallons per minute feeder which was visible in the shaft on its previous examination three and a half years before, there was now only a small feeder of 25 gallons per minute, this latter being entirely sealed off after a few hours' further injection.

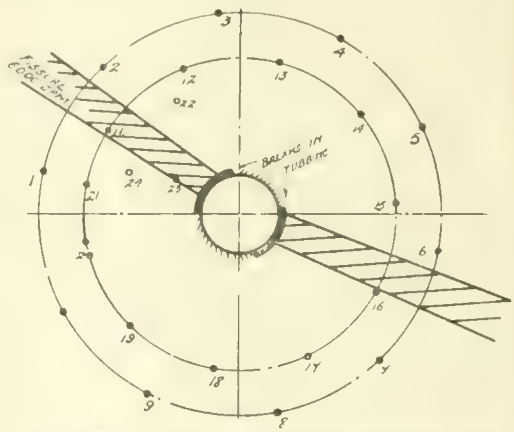


FIG. 2. PLAN OF CEMENTATION HOLES FOR THE REPAIRING OF TUBBING DESTROYED BY EXPLOSION.

Diameter of Shaft 16 ft.; Diameter of Outside Ring of Holes 84 ft.; Diameter of Inside Ring of Holes 68 ft.; Depth of Holes 360 ft.; Depth of Break in Tubbing 190 ft.

The successful treatment of the pit is one worthy of record, for with the exception of the fact that it was known that the tubbing had been badly broken at a vitally important part and that the shaft and neighbouring pits were completely flooded to a few yards from the surface, no information was available that was of any assistance in the preparation of the scheme of treatment. The majority of the pits were damaged by the Germans towards the end of 1915, and in consequence it had been found that at times the wooden tubbing had suffered considerably. In such cases the affected parts were treated by injection from the inside of the shaft. As a result of the cementation of pit No. 11 and other pits in the neighbourhood it was possible to start pumping operations on a large scale.

Chemistry of the Earth's Crust.—The *Journal* of the Franklin Institute for December contains an article with this title written by Henry S. Washington, petrologist of the petrological laboratory at the Carnegie Institution, Washington. After brief consideration of the interior of the earth, the general characters of igneous rocks are discussed, and the presence of water

vapour and other gases in the magma, and its analogy with a salt solution, are pointed out. In the discussion of the mineral characters of rocks, stress is laid on the fact that the number of essential rock-forming minerals is very small. These are mostly silicates of Al, Fe, Mg, Ca, Na, and K. Any two or more of these minerals (with two exceptions) may occur together and in any proportions. The chemical characters of igneous rocks are summarized, and the ranges and maxima of the various constituents are given. The average igneous rock is considered and, after some discussion of the sources of error involved in the calculation, a new average in terms of oxides (based on 5,179 analyses) is given. The average rock is shown to be approximately a granodiorite. The average composition of the earth's crust in terms of elements is also given. Twelve elements (O, Si, Al, Fe, Ca, Na, K, Mg, Ti, H, P, and Mn) make up 99·61% of the crust. The elements are referred to two main groups in the periodic table: (1) The petrogenic elements, characteristic of, and most abundant in, the igneous rocks, of low atomic weight, and occurring normally as oxides, silicates, chlorides, and fluorides; (2) the metallogenic elements, rare or absent in igneous rocks, but occurring as ores, of high atomic weight, and forming in nature native metals, sulphides, arsenides, bromides, etc., but not primarily oxides or silicates. The suggestion is made that beneath the silicate crust of petrogenic elements is a zone essentially of nickel-iron, and beneath this a central core of the metallogenic elements. This vertical distribution is in accord with Abbot's view as to the distribution of the elements in the sun. In igneous rocks and minerals the elements show a correlation, in that certain of them are prone to occur with others, and a similar limited correlation is apparently true of the animal and vegetable kingdoms. The idea of "comagmatic regions," that is, the distribution of igneous rocks in regions of chemically related magmas, is discussed, and some of these are briefly described. The calculation of rock densities from their chemical composition is discussed, and the average chemical compositions and densities of the continental masses and oceanic floors are given. It is shown by these that the average densities of the continents, ocean floors, and various smaller regions of the earth stand in inverse relation to their elevations. The bearing of this relation of average density and elevation on the theory of isostasy is pointed out, and it is shown that the data presented are confirmative of the theory.

Nickel and its Uses.—In *Chemical and Metallurgical Engineering* for January 5, Paul D Merica commences a series of articles on nickel and its alloys. We quote herewith his notes on commercial nickel and its uses.

Nickel appears on the market in the following forms:

(*a*) Grains, cubes, rondelles, or powder, reduced at a low temperature from nickel oxide and not fused in the process of manufacture.

(*b*) Nickel deposited in concentric layers from nickel carbonyl and not fused in the process of manufacture.

(*c*) Nickel deposited electrolytically in the form of cathode sheets.

(*d*) Nickel in the form of blocks or shots made by reducing nickel oxide above the melting point of nickel and casting the resulting molten metal or pouring it into water.

(*e*) Malleable nickel made in the same manner as (*d*) but treated with some deoxidizer before pouring into ingots. This nickel appears in the usual commercial forms, rods, sheets, wire, etc.

Most of the commercial production of nickel falls in class (*d*).

The International Nickel Co. has described the grades of material which it produces and contributes the average analyses of the materials given in the following table.

	Percentage Ni and Co.
1. Malleable Nickel Rods, A	99·00
2. " " " B	98·75
3. " " " C	96·75
4. Nickel Castings	98·95
5. Orford Electrolytic Nickel	99·84
6. Nickel Shot A	98·65
7. Nickel Shot X	99·05

The impurities were as follows: In (1) 0·55 Fe, 0·025 S, 0·10 Si, 0·15 C; and 0·15 Mn. In (2) 0·50 Fe, 0·025 S, 0·20 Si, 0·15 C, 1·75 Mn. In (3) 0·75 Fe, 0·03 S, 0·20 Si, 0·15 C, 1·75 Mn. In (4) 0·50 Fe, 0·035 S, 0·16 C. In (5) 0·01 Cu, 0·005 S, 0·005 C, 0·01 As, 0·01 Sn and Sb. In (6) 0·15 Cu, 0·80 Co, 0·50 Fe, 0·06 S, 0·15 Si, 0·45 C, 0·015 As, 0·015 Sn and Sb. In (7) 0·15 Cu 0·80 Co, 0·47 Fe, 0·04 S, 0·10 Si, 0·18 C, 0·015 As, 0·015 Sn and Sb.

"A" shot nickel is a high-carbon nickel used by manufacturers of anodes for nickel plating. "X" shot nickel is a purer material used by the manufacturers of crucible nickel steel and of nickel silver. Ingot or block nickel is almost identical in composition with "X" shot. It is sold in 25 lb. and 50 lb. blocks or ingots and is used in the manufacture of open-hearth and electric steel. Electrolytic nickel in the form of cathodes 24 by 36 in., weighing about 100 lb., or in smaller squares, and is used in the manufacture of high-grade nickel silver and cupro-nickel alloys. Malleable nickel intended for rolling into sheets or rods or for drawing into wire is made in various grades according to the purpose for which it is destined. All malleable nickel is treated before casting into ingots with some deoxidizer, generally magnesium, for the purpose of removing the nickel oxide present and making the metal suitable for rolling or forging. Manganese is also added both for the purpose of cleaning the metal and as an alloying element. Nickel cannot in general be rolled or forged without this preliminary treatment with a deoxidizer. Grades A and C malleable nickel ingots are used for rolling into rods and sheets and drawing into wire. There is also a grade D malleable nickel, which is high-manganese nickel having practically the same analysis as grade C, except that manganese varies from 2 to 5%. This is used principally for spark-plug wire to resist the action of high temperatures and combustion gases.

Besides these commercial forms of nickel, the metal is on the market in the form of anodes for the metal-plating industry. These cast anodes are variable in composition and contain from 88 to 95% nickel, together with iron, aluminium, tin, silicon, sulphur, and carbon. A typical analysis of a commercial anode is the following: graphitic carbon 1·70%, silicon 0·50%, iron 0·80%, copper 0·15%, aluminium 0·03%, nickel 96·82%.

The principal commercial application of nickel is in the manufacture of nickel steel, and this industry absorbed fully 75% of the total nickel production during the war and probably 65% normally. Besides its use in steel, nickel is used extensively as an alloying element with non-ferrous metals, principally copper. About 15% of the production is utilized in the manufacture of alloys of nickel, such as cupro nickel and nickel silver, the former series of alloys having come into prominence during the war. Nickel coinage and the electroplating industries may each absorb from 3 to 5% of the production, the latter requiring the metal both in the metallic form and in the form of nickel salts, the sulphate and double ammonium sulphate. The production of malleable nickel, although never relatively large, has amounted to about 5% of the total production, and is steadily growing in volume as the properties of the metal in this form become better known. Malleable

nickel is produced in all commercial forms and is used principally for coinage, cooking utensils (chiefly in Germany and Austria) and ornamental and household stampings and fittings. In the form of wire it is much used for motor-ignition spark-plug points, for the suspension wires in electric light bulbs, for electrical resistance pyrometers, electrical instruments, and recently in the construction of the audion amplifier. Some malleable nickel is produced in the form of castings for apparatus such as digesters and evaporators for the chemical industry, for which its resistance to corrosion in sulphuric and other acids makes it particularly suitable. The Edison storage cell contains nickel both in the form of nickel oxide and as nickel anodes. Finely divided nickel is much used as a catalytic agent in the hydrogenation or hardening of oils, following the discovery of this property by Sabatier and Senderens. Nickel oxide is used in the ceramic industries for the production of under or holding coats of enamel on steel, and also for colouring glazes on pottery. Nickel castings have been used with much success as rabble shoes by the International Nickel Co., in calcining furnaces used in roasting nickel matte. The shoes are exposed to oxidizing and to sulphurizing gases at temperature from 600 to 1,000° C. and to severe mechanical abrasion; they have stood up in this severe service for nine months, whereas iron shoes would last no more than from six to eight weeks.

Mica in Australia.—In the *Queensland Government Mining Journal* for October, B. Dunstan, Chief Government Geologist, gives an account of the mica production of the world. We extract the portion dealing with Australian occurrences.

Pegmatite veins containing large crystals of mica are known to occur on many of the mining fields of Northern Queensland, the deposits on the Einasleigh River to the south-east of Georgetown and at Brookland near Junction Creek, both within the Etheridge goldfield, being specially worthy of note. Attention has been directed to the occurrence of deposits in the Cloncurry district, and from recent examinations they appear to be of more importance than anything previously known in the State. They are situated on Rifle Creek, a tributary of the Upper (West) Leichhardt River, on Parkside No. 6 Pastoral Lease, and about 68 miles almost due west of the town of Cloncurry. Many references are given in the Queensland Mineral Index to mica occurrences, but without any information regarding their extent or value. As regards other occurrences in Australia, in the Northern Territory a mica mine was opened and abandoned some years ago at Hart's Range, to the north of Arltunga goldfield; in 1914 operations were again started, the war, however, stopping the work at the mine in consequence of the mica being intended for Germany. In South Australia it is reported to occur in an area near Williamstown, in the hundred of Barossa, and a low-grade deposit has been opened near the Warren Reservoir in the hundred of Para Wirra.

The country about the Rifle Creek mica area near Cloncurry is said to be in hornblendic and micaceous schist, in which a dyke of pegmatite was discovered to be made up almost exclusively of large crystals of mica, the thickness of the dyke being from 10 to 12 ft. A large number of pegmatite dykes, some with quartz predominating, occur in the locality, but have not been examined, although the mica-bearing belt is said to extend for several miles. Samples for examination have been received from the outcrops of these deposits, but no [illegible]s to have been made to determine the [illegible]ality of the mica below the surface [illegible] much stained with iron oxides, and [illegible]ry defective condition, as might be expected, but no doubt any blemishes in this surface material would disappear if the mica were obtained in deeper ground. Some of the crystals have well-developed cleavages, are roughly 9 in. square, and after being stripped and trimmed, even in their weathered condition, have given very satisfactory tests, electrical and otherwise. The deposits near Arltunga are in mica schist in the form of large pegmatite dykes of felspar, quartz, and mica. Some of the mica crystals obtained were several feet in diameter, and one specimen is said to have yielded 7 cwt. of trimmed mica sheets.

The question for consideration so far as Queensland is concerned is whether the Rifle Creek deposits contain mica equal in quality to that imported from America and India, and if so whether mining and dressing operations could be carried on cheaply enough to allow of competition with this imported material. Imperial demands for mica in connection with electrical and wireless work have stimulated the interest in these deposits and should induce miners to open up the outcrops, and obtain some estimate of the value of the very large mica sheets at a depth where they are not affected by weathering agencies. The distance from Rifle Creek to Cloncurry is 68 miles by road, and from Cloncurry to Townsville by rail 481 miles, altogether making 549 miles over which the product would have to be carried. In the mineral belt of country extending for many miles to the north-west and south-east of Cloncurry, and embracing the Rifle Creek deposits to the west, there is a large number of outcrops of granite and schist which all appear to be the result of the alteration of the associated sedimentary rocks. This area contains pegmatite dykes in the granites and schists which have never been prospected and the conditions are ideal for the occurrence of mica in qualities and sizes suitable for manufacturing purposes.

Vanadium in the Transvaal.—In the September issue reference was made to a company called the African Vanadium and Lead Co., formed in the Transvaal for the purpose of working lead-vanadium deposits at old Doornhoek lead mine, 17 miles south-east of Zeerust. The November issue of the *South African Journal of Industries* publishes the report made by Malcolm Ferguson, Inspector of Mines, Krugersdorp, and Dr. P. A. Wagner, Government Geologist. This report is reproduced herewith.

The deposit occurs in the upper portion of the dolomite formation. It consists of soft decomposed bedded manganese earth containing thin layers of chert and large masses and boulders of unaltered dolomite. Galena is scattered through the manganese earth in irregular nodules ranging in diameter from a fraction of an inch to over 2 ft. The nodules are often covered with a thin film of brilliant red minium, and some of them show traces of the original bedding of the dolomite. In addition, cerussite, vanadinite, and pyromorphite are present. These minerals occur in irregular layers following the bedding of the manganese earth, also in pockets, and finally encrusting vertical and steeply-inclined joint-planes. In the eastern part of the workings there is a big exposure of dolomite containing irregular masses and patches of galena, which has clearly developed by the replacement of the dolomite. It is associated with fluor-spar and talc. Whether this dolomite forms part of a great horse in the manganese earth, or whether it represents a projecting portion of the wall of the deposit, is not clear.

The deposit clearly owes its origin to a long and complex succession of metasomatic processes. In the first place galena appears to have been introduced from a series of inclined fractures striking N.E.-S.W. by mineralizing solutions that spread along the bedding planes

of the dolomite. The alteration of that rock to manganese earth took place subsequently, in all probability through the agency of descending meteoric waters. The formation of the vanadinite appears to have been connected with the conversion of the dolomite into manganese earth, but the evidence on the point is not quite conclusive.

The mine is situated on the east side of a valley, and has been opened by quarrying into the side of the hill, and up to the present the work has consisted mainly in turning over the quarried earth and extracting by hand the galena lumps which are sufficiently large to be picked out. Additional amounts of galena have been recovered from shafts sunk from the surface outside the quarry and from drives driven off the shafts and pushed in from the faces of the quarry. The eastern face of the quarry against the hillside is about 100 ft. high. The walls of the quarry practically everywhere appear to carry lead minerals. The mineral-bearing deposit is found to continue in the floor of the quarry and in the shaft and underground workings beyond, so that it is at present impossible to estimate the probable extent of the deposit. A rough traverse by prismatic compass was made of the most westerly underground workings at the 60 ft. level, and some samples were taken for analysis. Further samples were taken at various parts of the face of the quarry, and one from the dump. In the underground workings above referred to, and at the lower portion of the western face of the quarry, lead and vanadium ores were found to occur in fairly consistent quantities throughout the deposit over a considerable area and thickness. These workings cannot be looked upon as having opened up any tonnage of ore reserves. They merely serve to prove that the deposit exists over an extended area and carries the minerals referred to beyond the horizon of the present workings. The samples taken on the face of the quarry show the consistent nature of the lead contents throughout the deposit. The writers are of opinion that a considerable deposit carrying lead and vanadium ores exists, but that the extent of it cannot be determined at present.

Dr. James Moir, Government Mining Chemist, reports as follows on seven specimens of ore from the Doornhoek mine:

	Lead.	Vanadium Pentoxide.
	%	%
A.	9·95	0·90
B.	11·5	0·60
C.	8·15	0·45
D.	15·5	1·35
E.	14·3	0·40
F.	14·4	Uncertain trace.
G.	14·3	Trace about 0·2%.

Antimony Oxide as a Pigment.—At a meeting of the Oil & Colour Chemists' Association held last month, H. E. Clarke gave particulars of a new antimony oxide pigment put on the market under the name "Timonox." This pigment is said to be free from coarseness of crystalline structure and yellow impurity that have been the great drawbacks in the past. Two brands have been introduced, the "red star" being a very pure white colour, and the "green star" a pale ivory cast. The specific gravity of this antimony oxide is about 5·4, which is approximately that of zinc oxide. The two pigments, however, differ sharply in their behaviour with oil; antimony oxide is readily wetted, while its oil absorption is so much lower that good paste can be ground containing 10% of oil. It is said to be possible to prepare from such paste oil paints with as much as 78% pigment, which flow well under the brush and give coats of great opacity and purity of colour. For glossy finishes good results are obtained with about 10% le pigment. The drying rate is carefully adjusted, as there would seem to be a tendency to flatting when the drying is unduly delayed. Matt and semi-glossy effects are readily obtained. Antimony oxide has been found to have no accelerating effect on the drying of linseed oil, but this deficiency can be overcome by the incorporation of a small proportion of drier. This may take the form of litharge, white lead, manganese borate, zinc oxide, gold size, or a drying resinate or linoleate. These mixtures, however, require to be broken with rather more oil and less volatile thinner than white lead pastes. Durability and colour stability tests have shown that this pigment has excellent wearing properties. The films show practically no cracking and very little chalking. Zinc oxide has proved itself a useful auxiliary to antimony oxide, acting first as a drier and later as a hardener of the film.

Geology of Killifreth Mine.—At a meeting of the Royal Geological Society of Cornwall, held in November, M. H. Kitto read a paper describing the geology of Killifreth mine, near Redruth, with special reference to the middle lode. The mine is situated in the clay-slate a mile and a half north of the granite outcrop, but granite is met with in the 70 fathom level in the form of a tongue or apophysis, and again as a tongue in the 20 fathom level, where it is seen to pass into schorl rock. Quartz-porphyry dykes are met with at the 50 fathom level and again in the 40 fathom level. The middle lode has yielded blende, cassiterite, chalcopyrite, mispickel, molybdenite, pyrite, and wolfram, while smaltite has been found in a cross-course. The mineral values are irregularly distributed. The lode shows comb structure and in places is filled with cassiterite in tourmalinized slate, clean quartz with wolfram, clean quartz with wolfram and molybdenite in separate layers The author comes to the conclusion that there has been chiefly lateral movement with little or no vertical displacement in the cross-course which cuts the middle lode.

Geology of Carn Marth.—At a meeting of the Royal Geological Society of Cornwall, held in November, G. M. McPherson, Jr., read a paper on the geology of Carn Marth, and of the district lying immediately to the east of Redruth. He describes some interesting cases of differentiation in the granite and concludes that four types of rock are represented: (1) the original coarse muscovite biotite granite which forms the bulk of the mass; (2) an intrusion of fine-grained granite which penetrated the coarse type with an irregular line of contact along which it is seen to contain coarse crystals of felspar; (3) an intrusion of fine-grained schorl granite which penetrates the fine granite but does not reach the coarse type; (4) an intrusion of pegmatite, and in the coarse granite only narrow dykes of aplite. The author also describes a contact of two quartz-porphyry dykes (elvans) which occurs at the junction of the granite and clay-slate.

SHORT NOTICES.

Mine Signalling.—The *Colliery Guardian* for January 7 describes the Granville audible and visual signalling apparatus, as applied at the Granville colliery, Burton-on-Trent.

Ventilation in Mines.—The November *Journal* of the Chemical, Metallurgical, & Mining Society of South Africa contains an article by E. J. Laschinger describing ventilation tests at Village Deep undertaken with the object of ascertaining the amount of fresh air required to remove the fumes after blasting in development drives.

Kata-thermometer. In a paper published in the November *Journal* of the Chemical, Metallurgical, & Mining Society of South Africa, H. J. Ireland describes Dr. Leonard Hill's kata-thermometer, which is used for measuring the cooling power of the atmosphere.

Copper Smelting in Japan. In the *Engineering and Mining Journal* for January 8, C. F. Mason describes the operation of the Hidachi copper smelter in Japan.

Bunker Hill.—In the *Mining and Scientific Press* for January 8, T. A. Rickard describes the Bunker Hill & Sullivan Company's lead-smelting plant.

Cadmium. *Chemical and Metallurgical Engineering* for December 29 contains a paper by H. R. Hanley on an electrolytic process for producing cadmium as devised by the author at the Mammoth electrolytic zinc plant of the United States Smelting, Refining, & Mining Co., at Kennett, California.

Cyaniding. — In the *Engineering and Mining Journal* for January 15 and 22, Alfred James reviews the position of the cyanide process.

American Sulphur.—*Chemical and Metallurgical Engineering* for January 12 reprints a paper read by R. F. Bacon and H. S. Davis before the American Institute of Chemical Engineers on December 6, describing the American resources of elemental sulphur, particularly those in Texas, and comparing the relative advantages of pyrites and sulphur as a source of sulphuric acid.

Midland Coalfields.—A paper was read by H. H. Ridsdale at the January meeting of the South Staffordshire and Warwickshire Institute of Mining Engineers on the geological relationship of the South Staffordshire, Warwickshire, South Derbyshire, and Leicestershire coalfields.

Oil in India.—The *Geological Magazine* for January contains a paper on the geology of the oil regions in the northern Punjab, India, by H. Preiswerk.

Old Sussex Iron Industry. — At the meeting of the Newcomen Society, held on January 27, Rhys Jenkins read a paper on the rise and fall of the iron manufacture in Sussex.

World's Copper Production.—In the *Geological Magazine* for January, Dr. F. H. Hatch writes on the growth of the world's copper production.

Low-Temperature Carbonization.—At a meeting of the Society of Chemical Industry held on January 3, G. H. Thurston read a paper describing the Smith low-temperature system of carbonization.

Building Stones.—At the meeting of the Concrete Institute held on January 27, J. Allen Howe read a paper on geology in relation to building stones.

Cementation at the Mazoe Dam.—In a paper published in the November *Journal* of the Chemical, Metallurgical, & Mining Society of South Africa, G. A. Voskule described the hardening of the substrata of the Mazoe dam in Rhodesia, effected by means of the Francois cementation process.

Trestle Viaducts.—The *Engineer* for January 21 gives particulars and drawings of the old timber viaducts on the Great Western Railway in Cornwall and Devon. These bridges were built in Brunel's days, but have gradually been replaced by stone viaducts. At present two are being removed on the Kingswear branch and two of the eight on the Falmouth branch are to be removed shortly.

Arthur De Wint Foote.—The *Mining and Scientific Press* for December 25 contains the report of an interview between Mr. Foote and Mr. T. A. Rickard giving the former's record. Mr. Foote's work at the North Star gold mine, in Grass Valley, California, is of great interest to mining engineers.

RECENT PATENTS PUBLISHED.

☞ *A copy of the specification of any of the patents mentioned in this column can be obtained by sending 1s. to the Patent Office, Southampton Buildings, Chancery Lane, London, W.C. 2, with a note of the number and year of the patent.*

14,865 of 1917 (155,600). C. J. HEAD, London. Production of tungsten powder by heating sodium with sal ammoniac and carbon.

4,376 of 1919 (155,855). A. R. MANGNALL, Chester. Boring machine for forcing a heading through soft ground.

11,184-6 of 1919 (126,625-7). P. DESACHY, Paris. Method of preparing an anhydrous zinc sulphide from hydrated sulphide precipitated from solutions by chemical reactions.

19,316 of 1919 (142,432). C. P. MADSEN, Newark, New Jersey. Improved method of electrolytic plating with nickel.

20,891 of 1919 (125,875). W. BROADBRIDGE, E. EDSER, W. W. STENNING, and MINERALS SEPARATION, LTD., London. In the separation of coal from stone by the agitation-froth method the use of a flocculating medium which will serve as a binding agent in the production of briquettes.

22,174 of 1919 (137,273). BROWN, BOVERI & Co., Baden, Switzerland. In air-compressors of the rotary type, methods of preventing the surging of the delivery.

22,370 of 1919 (155,349). L. A. WOOD and MINERALS SEPARATION, LTD., London. In the agitation-froth concentration process, in which air is introduced below the agitator, the arrangement of a grid just above the agitator.

22,825 of 1919 (155,373). H. T. ARROWSMITH, Burslem. Method of making acid pots used in the manufacture of white lead.

23,352 of 1919 (155,644). G. HENZE and E. WEBER, Brussels. An internal combustion engine suitable for use on mine locomotives.

25,545 of 1919 (155,945). P. A. MACKAY, London. Method of making sulphate of lead from metallic lead by the attack of strong sulphuric acid.

26,231 and 28,489 of 1919 (155,692). J. J. HOOD, London. Method of purifying sulphur.

26,310 of 1919 (155,953). G. BECKER, Magdeburg, Germany. Improvements in conveyors of the jigging type.

27,784 of 1919 (135,186). AKTIEBOLAGET FERROLEGERINGAR, Stockholm. Method of preparing manganese and manganese alloys low in carbon and silicon.

27,785 of 1919 (135,187). AKTIEBOLAGET FERROLEGERINGAR, Stockholm. Method of removing silicon and carbon from chromium and chromium alloys.

1,715 of 1920 (138,083). W. FRIEDERICK, Cologne. Detonating caps, loaded with a suitable nitro compound, primed with an initial charge of lead azide, and lead tri-nitro-resorcinate placed over it.

3,279 of 1920 (139,160). B. RAEDER and A. S. ZINK CO., Christiania, Norway. Arrangement of drying, heating, and reduction chambers in electric furnaces for producing zinc.

3,892 of 1920 (155,145). G. H. ELMORE and H. L. MCLEAN, Scranton, Pennsylvania. Jigs for coal washing.

4,369 of 1920 (138,924). NEW JERSEY ZINC CO., F. G. BREYER, and E. H. BUNCE, New York. Method of treating impure zinc oxides by heat for the improvement of their colour and their suitability for use as pigments.

5,532 of 1920 (156,019). J. DEAN, Racine, Wisconsin. Mechanical method of preparing the surface of aluminium to permit of coating, tinning, or soldering.

6,049 of 1920 (139,520). SOCIÉTÉ ANONYME DES CHARBONNAGES DE BEERINGEN, Liége. Improvements in the method of shaft-sinking by means of freezing.

9,633 of 1920 (155,739). METAL & THERMIT CORPORATION, New York. Method of introducing tungsten metal into molten steel for the formation of tungsten steel.

15,884 of 1920 (144,728). FRIED KRUPP GRUSONWERK, Magdeburg-Buckau, Germany. Improvements in the chloridizing-roasting process, particularly with the object of separating lead and silver from complex zinc-lead ores.

16,162 of 1920 (145,047). SIEMENS-SCHUCKERTWERKE, Berlin. Improved transporter for use in connection with tunnelling and mining machines.

16,559 of 1920 (146,108). R. M. MCKENNA, Washington, U.S.A. Purification of ferro-tungsten, by treating with hydrochloric acid for the removal of sulphur, carbon, and phosphorus.

17,690 of 1920 (155,522). L. A. IRAZUSTA, Guipuzcoa, Spain. Use of pure alumina and water as binding agent for fine iron ores, in the manufacture of briquettes for smelting

17,760 of 1920 (145,600). P. GOLDBERG, Berlin. Electrolytic process for separating copper and nickel.

24,854 of 1920 (151,260). G. HAGLUND, Falun, Sweden. Improved electrolytic cell for the deposition of nickel from solutions.

NEW BOOKS, PAMPHLETS, Etc.

☛ Copies of the books, etc., mentioned below can be obtained through the Technical Bookshop of *The Mining Magazine*, 724, Salisbury House, London Wall, E.C.2.

Coal; being one of the Monographs on Mineral Resources with Special Reference to the British Empire, issued by the Imperial Institute. By J. H. RONALDSON, M.Inst M.E., M.Inst.M.M., F.G.S. Paper covers, octavo, 166 pages. Price 6s. net. London: John Murray.

In this little volume Mr. Ronaldson has attempted the almost impossible task of producing an account of the coal resources of the entire British Empire. To do this adequately, many such volumes and at least as many authors would be needed; no one man can possess all the requisite information, and no one book can contain it. Mr. Ronaldson's book is of course only a compilation of matter already published, but it can fairly claim to present in a convenient form a sketch of the coalfields of the British Empire and to act as an index to the vast mass of scattered publications on the subject. The author has of course drawn mainly upon the great work, "The Coal Resources of the World," published in 1913 in Canada under the auspices of the International Geological Congress, and most of the statistics given are quoted from this. Unfortunately the author has drawn some of his statistical matter somewhat indiscriminately from other sources, as, for example, for Great Britain from the Report of the 1904 Commission on Coal Supplies or from Hull's work on the Coalfields of Great Britain, and uses at times the figures from one source, at times from another, and even in places puts down two sets of estimates and leaves it to the reader to select whichever he may happen to fancy. The same want of care in the due co-ordination of his sources of information may be seen in such an example as in the spelling of the same coalfield as "Jharia" and "Jherria" respectively on two adjoining pages. The portion of the book that will probably strike the reader as the least satisfactory is that relating to the coalfields of Great Britain, though this may be merely due to the fact that information concerning these is better known and more readily accessible. It is noteworthy that Mr. Ronaldson has given only 15 references to literature concerning the United Kingdom, and has omitted some of the most important; thus he would no doubt have written differently from what he has done had he consulted Stanley Smith's work on the Limestone Coals of the Northumberland coalfield, while again he seems to have made no use of A. E. Ritchie's book on the Kent coalfield. It is at least as surprising that he has not availed himself of the mass of valuable matter to be found in the Transactions of the Institution of Mining Engineers. In spite, however, of such imperfections and limitations, the book should be found decidedly useful to a wide circle of readers, particularly if care is taken to consult on all matters of detail the more extensive works, of which the present volume may be regarded in the light of a convenient abstract.

HENRY LOUIS.

The Platinum Metals. By A. D. LUMB, A.R S.M., F.G.S., Assoc.Inst.M.M. Octavo, paper covers, 63 pages. Price 3s. 6d. net. London: John Murray.

This book is one of the monographs on mineral resources with special reference to the British Empire, prepared under the direction of the Imperial Institute. The 63 pages are divided into three chapters. Chapter I deals with the occurrences, characters, and uses of the platinum metals, and contains interesting tables giving various analyses of platinum from different parts of the world, a list of the principal platinum and palladium alloys, the world's output of platinum from 1910 to 1918, and others. As regards the world's output of platinum, the author on page 13 mentions that "it appears to have been a tendency for private enterprises (in Russia) to keep these published outputs as low as possible in order to avoid registration." In this respect the author is wrongly informed, and such a serious statement should certainly never have been made without closer investigation. The real discrepancy between official and actual figures is solely due to theft either by workmen from their employers or by marauders working without licence or authority. Chapter II, which deals with the sources of supply of the platinum metals from the British Empire, contains in condensed form descriptions of occurrences throughout the Empire. It is very complete and useful. Chapter III is devoted to the supply of platinum metals from foreign countries. It lacks accuracy; the geological data for some of the countries are decidedly antiquated and a good many mis-spellings (or are they printer's errors?) should have been avoided. In France there is no Department of "Charaste," but "Charente"; "Chatelard" is given as "Chatalard"; in French Guiana the river "Aporuague" should be "Apronaguel" and "Danmer" should be "Damour." The platinum deposits in Germany, according to the author, are quite real and practically ready to start exploitation. Yet Krusch, the author cited, entitles his treatise on these deposits: "Die *Platinverdächtigen* Lagerstätten etc," that is, the deposits *suspected* of containing platinum, etc. Krusch cites assay-results made by one and the same method, on the same material but in different laboratories, thus:

	1st Laboratory Grammes per Ton.	2nd Laboratory Grammes per Ton.
No. 1	30 00	Traces
No. 2	35 05	3 8
No. 3	8 00	0 8

In the face of such facts, by simply saying that his

samples yielded values varying from a trace to 33.5 grammes per ton, a wrong impression is being conveyed. The German deposits from a technical point of view are far from being proved. As regards Russia, the statistical data are substantially correct, but the geography dealing with the deposits is not properly co-ordinated and rather confusing, even wrong. Describing the methods in use in certain parts of Russia when working the deposits in winter, the author states (page 40) that the deposits are allowed to freeze and the frozen ground is mined after having partially thawed. This method is, however, only resorted to for prospecting purposes, as has been extensively described in Leon Perret's paper in Volume xxi. of the Transactions of the Institution of Mining and Metallurgy. The references to literature on the platinum metals, while extensive in many instances, are second-hand; besides, they are not sufficiently up to date. A publication by Visotski is mentioned which dates back to 1903 and which in the original is entitled "*Preliminary* Notice on the Platinum Deposits, etc." His completed treatise was published in 1913 and bears the title "The Alluvial Platinum Deposits of the Iss and of Nijny Taguil in the Urals." The latter publication should have been consulted. Some of the eminent workers on the geology of platinum deposits are not mentioned at all, for instance, Feodoroff, Nikitin, Levinson-Lessing, etc. The book under review is framed on a comprehensive basis and deserves re-editing. Its shortcomings could readily be amended; they should certainly not have escaped the vigilance of the scientific and technical staff of the Imperial Institute.

A. L. SIMON.

Geology of the Non-Metallic Mineral Deposits other than Silicates. Volume I. Principles of Salt Deposition. By AMADEUS W. GRABAU. Cloth, octavo, 430 pages, illustrated. Price 30s. New York and London: The McGraw-Hill Book Co.

Those who have carefully studied the author's "Principles of Stratigraphy" will welcome the appearance of the present volume, which deals in a most lucid manner with the practical application of those principles in so far as they affect salt deposition. In this term "salt" are included nitrates, phosphates, borates, common salt, and similar deposits, thus embracing a wide field of investigation, and the author has spared no pains to treat the subject as systematically and originally as he expounded his theories of stratigraphical geology in his former standard work, though with this exception: that a somewhat heavy style and cumbersome nomenclature characteristic of the "Principles" find no place in this later production, to its very distinct advantage.

As in so many phases of applied stratigraphy, our knowledge of the geology of salt deposits has its decided limitations, and even the standard textbooks are astonishingly vague or stereotyped in their treatment of the matter; certain well-defined theories of salt deposition (using the word salt in its more restricted sense), modelled on the lines of the famous Stassfurt occurrence, recur in nearly every publication on the subject with monotonous frequency, with little, if any, review or modification in the light of advancement of general ideas on stratigraphy. There is nothing vague or stereotyped in this book, and its advent anticipates and lays the foundation for a distinct line of progress to be followed in future researches of this branch of economic geology.

The author first considers the natural salts, their mineral characteristics and classification from a strictly chemical standpoint; this includes a valuable glossary of the principal properties and mode of occurrence of the non metallic salts (other than silicates), oxides, hydrocarbons, and non metallic native elements. This is followed by a very succinct account of Van 't Hoff's famous researches on oceanic deposition, illustrated by saturation and crystallization diagrams, in the chapter dealing with the sea as a source of saline deposits; in this chapter, Grabau's treatment of the biological factors involved is good, but we would have preferred a fuller discussion of the parts played by marine bacteria and algæ in the secretion of lime salts than he has given us, on the lines of Drew's excellent paper of 1914 (Carnegie Institute of Washington), to which the author makes only passing reference. Although he anticipates this criticism in the preface to a certain extent, it is doubtful whether a sudden flood of illustrations of modern and extinct organisms included at this stage makes up for the omission of details so essentially cognate to the subject. The succeeding four chapters are devoted to a consideration of the several phases of marine salt deposition, and include a short description of those interesting "cyclic salts," illustrated with reference to Holland and Christy's account of the well-known Sambhar Lake of Rajputana. This type of deposit is defined as salt which has been lifted from the sea with the spray, blown inland and deposited either near to the coastal margin, or under special circumstances (as at Sambhar) in inland drainage basins.

The next section deals with terrestrial salt deposition, and in our opinion is the most valuable part of the book; all deposits of this description are classified with reference to both the source of the material and the cause of deposition; with this as a basis, the reader is presented with a very able thesis on this phase of the subject. In particular chapters 9 and 10 deserve special mention; in the former he discusses "connate salts," a phrase happily chosen to define a type of inorganic sediment of which little account is usually taken by the average geo-physicist. Connate salt implies just that deposit derived from seawater and enclosed with the sediments actually laid down therein, and when not removed by subsequent leaching action, constitutes a fundamental factor in the formation of salt deposits, and one hitherto unappreciated at its full stratigraphical significance.

The succeeding pages are devoted to a consideration of nitrates, phosphates, and salts derived from hot springs, mineral springs, and the like, and in the penultimate chapter the author discusses several theories of origin of those curious salt-dome structures which are so imperfectly understood and at the same time of such far-reaching importance, particularly in oilfield technology.

We strongly recommend this volume to all those interested in problems of salt deposition and economics, and we look forward to the promised volume 2, and also to the volume on hydrocarbons at which the author hints in his preface.

H. B. MILNER.

Mineralogy. By Drs. E. H. KRAUS and W. F. HUNT Cloth, octavo, 580 pages, illustrated. Price 27s. net New York and London: The McGraw-Hill Book Co

The volume is described as an introduction to the study of minerals and crystals. In the introduction the authors point out the intimate connection between mineralogy and mining and agriculture, and hence also commerce and industry generally. Its relations to the other sciences is indicated, and its origin on a scientific basis is justly credited to Werner. The introduction is followed by chapters on crystallography, which are illustrated by photographs of actual crystals and crysta

models, in addition to line drawings. This should help the student, whose training in solid geometry is usually slight, to master the initial difficulties of the subject. Chapters dealing with the polarizing microscope and chemical properties of minerals follow, and the introductory matter is completed by chapters on the formation and occurrence of minerals and on qualitative blow-pipe methods. Descriptive mineralogy, including a chapter on gems and gem stones, occupies about 150 pages, followed by classification tables and a glossary of terms. The text is copiously illustrated by figures and photographs, and also by portraits of eminent mineralogists. The definitions of the terms "drusy" and "hydration" as given in the glossary might be improved, and it is to be noted that while the names of some plutonic rocks are given others are omitted. An inspection of the blow-pipe tests shows them to be complete and up-to-date, but it should be mentioned that some varieties of cassiterite refuse to yield a satisfactory result with the zinc and hydrochloric acid test. The book can be thoroughly recommended to the student as an introduction to the subject, and is especially suitable to one attempting to improve his knowledge of minerals without access to lectures and demonstrations.

E. H. DAVISON.

The Ore Deposits of Utah. By B. S. BUTLER, G. F. LOUGHLIN, V. C. HEIKES, and others. Professional Paper No. 111 of the United States Geological Survey.

A discussion of the numerous ore deposits of a State that has produced nearly a thousand million dollars worth of metals, and written by such a galaxy of eminent economic geologists as the experts of the United States Geological Survey, is a work of exceptional interest to mining geologists and engineers in general. Such is this volume. It contains accounts of copper, silver, gold, lead, and zinc deposits of great variety, besides descriptions of deposits of many other less common metals, together with critical discussions of the modes of genesis of the several kinds of deposits. While most of these deposits are derived from igneous sources, many occur in sedimentary formations often showing no obvious connection with igneous rocks and of doubtful affinities. Covering such a wide range of types the work is practically a textbook on ore deposits and their modes of genesis. It is profusely illustrated both with field photographs and photomicrographs illustrating important points in occurrence, and contains numerous statistical diagrams. Among features of special interest may be mentioned the descriptions of alunite veins and a critical discussion of the genesis of sulphuric acid under magmatic conditions and the general problems of primary sulphate veins. Alunite veins and alunitization are geological features that are particularly well developed in Utah. The volume also contains much information on the problems of metamorphism and some very interesting applications of quantitative methods for elucidating the probable characters of the solutions or emanations that have brought about metamorphic changes and the deposition of ore minerals. Altogether the work is one that may be studied with profit by all interested in the problems of ore occurrence and ore genesis.

W. H. GOODCHILD.

The Geology and Ore Deposits of Ely, Nevada. By ARTHUR C. SPENCER. Professional Paper 96 of the United States Geological Survey.

This volume is of great interest to the general student of ore deposits as a treatise on the occurrence and genesis of the huge disseminated copper or mineralized porphyry deposits that have contributed so largely to the establishment of America's pre-eminent position as the producer of such a large proportion of the world's copper supply. In addition to and apart from its local interest as a descriptive treatise on the ore deposits of a particular region, it is of special interest in that it gives a very full account of the processes of primary or igneous and secondary or katamorphic metamorphism, both of which processes have been necessary to generate rock sufficiently impregnated with metalliferous material to rank as commercial copper ore. The chemistry of secondary enrichment of lean primary iron and copper sulphides is discussed in considerable detail. The primary or igneous metamorphism and mineralization of the monzonitic porphyry intrusives, which carried little or no mineral as originally formed, is fully described, and the extensive changes wrought in the rock-masses are ascribed to magmatic waters emanating from an internal magma reservoir undergoing crystallization, the reservoir being the parent reservoir of the monzonitic extrusions. It is of interest and indeed somewhat striking that the theory of primary sulphide mineralization and wholesale metamorphism here quite independently put forward, as a result of careful and detailed geological surveying in this region, to account for the introduction of the enormous quantities of pyrite and accompanying copper, together with the accompanying silicate metamorphism, is identical in principle with the theory put forward elsewhere by the reviewer to account for the wholesale metamorphism of the Witwatersrand series and the introduction of iron sulphides and gold in large quantities into the conglomerates and their associated rocks. There seems to be a marked parallelism between the two types of occurrence, which, though differing considerably in detail, are closely allied in principle, so that it seems possible that a study of the copper porphyries of the New World might be helpful in the elucidation of the great gold problem of South Africa.

W. H. GOODCHILD.

Chemical Analyses of Igneous Rocks. By HENRY STEPHENS WASHINGTON. Professional Paper 99 of the United States Geological Survey.

This volume is a revised and greatly enlarged edition of the original tables of rock analyses collected by the same author, and published as Professional Paper 14 of the United States Geological Survey. This edition embraces the analyses of no less than 8,602 igneous rock samples as against 2,281 in the original paper. It is undoubtedly the most complete collection of igneous rock analyses extant and, having regard to the care with which it has been compiled, may be regarded as the standard work of reference on this important branch of petrological research. The tables give the analysis of each rock, together with its ordinary name, the locality from which the specimen was obtained, the name of the analyst, the bibliographical reference to the source of information, its position in the quantitative system, and remarks. To quote the author's words, "it is coming to be recognized by petrologists in general that the study of igneous rocks is in large part the study of silicate solutions and their equilibria, often complicated by the presence of volatile components, and is thus to be regarded as essentially a branch of physical chemistry." For such a study rock analyses are all-important and, indeed, indispensable. Hence the importance and value of this work to all geologists concerned with the study of igneous rocks, and, it may be added, to mining geologists in particular, since so many ore deposits are derived from such rocks or the molten masses from which they have crystallized. The tables are prefaced with a critical discussion of the character and use of such analyses and contain much in-

formation of value to geologists who may not be familiar with the chemical methods of rock analysis and the possible errors in ordinary rock analyses. The well-known quantitative system of classification is adopted in the presentation of the analysis. Whatever may be said as to the limitations and shortcomings of this system as at present developed, there can be no question as to the usefulness of this volume as a dictionary of igneous rock analyses. The construction of the system and a general explanation of its principles and practical working is given in an appendix, so that the work is complete in itself and can be used by those who may not be accustomed to its peculiar conventions and usages. The work is one that should find a place in the library of every petrologist and mining geologist.

W. H. GOODCHILD.

Wire Ropes for Hoisting. Quarto, 284 pages, with many illustrations. Price 20s. net. Johannesburg: The South African Institution of Engineers.

This volume contains a reprint of extracts from articles, etc., appearing in the publications of the South African Institution of Engineers and of the previously existing societies of which it is the successor. The papers and articles are not by any means given in full. In most cases parts of the discussion are given also. The following are the titles of the papers: Winding Plants for Great Depths, by Hans. C. Behr (1902); Rope Statistics, extracted from *Glückauf* (1903); Notes on the Corrosion of Wire Ropes by Mine Waters, by W. S. Thomas (1904); An Investigation Regarding the Effect of Kinetic Shocks on Winding Ropes in Vertical Shafts, by J. A. Vaughan (1904); The Risk Arising from Using Winding Ropes with too High an Initial Factor of Safety, by H. J. S. Heather (1905); Some Interesting Repairs to Machinery, by K. Schweder (1906); Wire Ropes Used for Winding: Their Strength and Some Causes for its Reduction, by J. A. Vaughan and W. M. Epton (1905); Some Notes on an Electrical Apparatus for Ascertaining the Cross Sectional Area of Wire Ropes, by C. McCann (1906); A Few Notes on Results of Tests of Worn Ropes, by W. M. Epton (1907); Record Keeping as Applied to the Resident Engineer's Department of a Mine, by H. L. Templer (1909); The Kimberley System of Handling Large Quantities of Ground in the Minimum of Time, with Notes Regarding the Life of Wire Ropes, by A. F. Williams (1911); Notes on the Margin of Safety Required by Government for Man Haulage at Great Depths, by R. B. Greer (1912); Hauling from Great Depths, by H. Kestner (1913); Notes on the Value of Annealing the Connecting Attachments on Winding Plants, by J. A. Vaughan (1916); The Factor of Safety of Wire Ropes Used for Winding in Mine Shafts, by J. A. Vaughan (1917).

Geology of the Northern Portions of the Districts of Marico and Rustenburg, Transvaal. By H. KYNASTON, W. A. HUMPHREY, and A. W. ROGERS. Pamphlet and maps published by the Geological Survey of South Africa.

Geology of Pondoland. By A. L. DU TOIT and A. W. ROGERS. Pamphlet and map published by the Geological Survey of South Africa. The copper-nickel deposits at Insizwa lie on the north-western border of the area covered by this work.

The Limestone Resources of the Union of South Africa II. By W. WYBERGH. Memoir No. 11 of the Geological Survey of South Africa, dealing with the limestones of Natal, the Cape, and Orange Free State.

Corundum in the Northern and Eastern Transvaal. By A. L. HALL. Memoir No. 15 of the Geological Survey of South Africa; 220 pages, with many maps and other illustrations. This volume gives detailed information as to the many corundum deposits of the Transvaal with an account of the geology of the country. A paper on this subject by Dr. P. A. Wagner was quoted in the MAGAZINE for September, 1918.

Asbestos 1913 to 1919. Pamphlet published by the Imperial Mineral Resources Bureau. Price 1s.

Manganese Deposits, Peak Hill Goldfield. By A. MONTGOMERY, State Mining Engineer for West Australia. This report describes manganese deposits at Horseshoe Range in the Peak Hill goldfield.

Geology of the Enterprise Mineral Belt. By H. B. MAUFE, Director of the Rhodesian Geological Survey. Geological Survey Bulletin No. 7.

COMPANY REPORTS

Wolhuter Gold Mines.—This company was formed in 1887 to work a gold-mining property on the outcrop on the central Rand. The control passed from the Neumann group a year or two ago to the Central Mining & Investment Corporation. The report for the year ended October 31 last shows that 396,292 tons of ore was raised, and, after the rejection of waste, 369,600 tons averaging 5·9 dwt. per ton was sent to the mill. The yield of gold by amalgamation was 71,841 oz. and by cyaniding 31,828 oz., being a total of 103,669 oz. or 5·6 dwt. per ton. The par value of this gold was £435,337, but an additional income of £133,000, arising from the premium, was realized. The working cost was £433,001, or 23s. 5d. per ton, leaving a profit of £135,336. Dividends absorbing £107,500 were distributed, being at the rate of 12½%. The ore reserve is estimated at 661,904 tons averaging 5·7 dwt. The mine is fully developed and the number of available stope faces is gradually decreasing. In order to maintain the output it becomes necessary to draw from reclamation sources ore of lower grade. Thus in the future smaller profits will be made, and it will only be by means of the gold premium that the mine can be kept working.

Messina (Transvaal) Development.—This company was formed in 1905 to work copper properties in the northern Transvaal. Though the ore was rich it was not possible for some time to make profits owing to the high cost of shipment to England. Subsequently, when treatment plant was provided, the richer ore had become exhausted. The only dividends paid were for the years ended June 30, 1916, and June 30, 1917. The cessation of shipments of matte during the latter part of the war was another adverse factor. As already recorded, it was decided recently to build a new mill and a new smelter and refinery, the financing of which was provided by a subsidiary company called the Transvaal Smelting & Refining Co., Ltd., which would treat other ores as well. The report for the year ended June 30 last shows that 11,659 tons, averaging 5·1% copper, was raised from the Vogelenzang mine, and 80,488 tons, averaging 2·51%, from the Messina mine. The results of concentration were: 55 tons of picked shipping ore and concentrate, averaging 68%, and 5,871 tons of concentrate, averaging 33·4%, suitable for smelting on the spot. The matte produced by smelting 6,284 tons of ore and concentrate was 3,036 tons, averaging 63·6%. Concentration and smelting were suspended at the beginning of May, owing to the operations not being profitable, and the building of the new plant was commenced. Owing to the usual delays it is not expected that the new plant will be finished until April of this year. The accounts show an income of £174,089 from the sale of products, and the adverse

balance was £124,424. The proved ore reserve at the Vogelenzang mine is estimated at 28,370 tons, averaging 5·12%, and at the Messina 124,071 tons, averaging 3·84%. Taking into account the probable and possible ore, these figures become 85,202 tons, averaging 3·72%, and 433,508 tons, averaging 3·14%, respectively.

Tanganyika Concessions.—This company was formed in 1899 by Robert Williams to develop lands in northern Rhodesia. The Kansanshi copper-gold mine was opened, but is not now being worked. Subsequently a 40% interest in the Union Minière du Haut Katanga was acquired. This Belgian company operates copper and other mines in Congo State. The report of Tanganyika Concessions for the year ended June 30 last shows that the output of copper during 1919 was 23,004 tons, and that the output for 1920 is estimated at 19,000 tons. The output of tin concentrate at the Busanga tin mine to August 31 last was 272 tons. The present output is about 50 tons per month, and is expected shortly to be increased to 80 tons. Prospecting for tin has been conducted at several points in the Kasonso district with encouraging results. Coal deposits have been discovered by drilling close to the railway near Sankishia, and the evidence indicates the coal to be of considerable extent. Combustion tests show that the coal is useful for steam-raising but not for coke manufacture. The company is also largely interested in the Benguella railway, the Katanga Railway, and the Rhodesia-Katanga Railway. Recently a substantial interest has been taken in the Nile-Congo Divide Syndicate, which has been formed to investigate mineral deposits in the Sudan along the Nile-Congo watershed. The utilization of water power derived from falls on the Lualaba and Lufira rivers is still under consideration, the chief object being to secure cheap electricity on a large scale for the electrolytic treatment of low-grade copper ores. As already recorded, the debentures have been paid off by means of funds raised by the issue of a million new shares at £3 each. The company has taken its proportion of a new issue made by Union Minière, namely, 9,800 shares at 800 francs each. The accounts show the receipt of a dividend from the holding in Union Minière shares, 4,900,000 francs, which, at 56·5 francs to the pound, realized £86,725. Interest on loans and investments brought £45,918. The net profit was £89,666, which was carried forward.

Wankie Colliery.—This company was formed in 1899 to acquire coal lands in Rhodesia, north of Living-

stone Falls, about 200 miles north-west of Bulawayo. The railway from Bulawayo northwards, passing through the property, was opened in 1903. Edmund Davis is chairman and managing director, and A R Thomson is manager. The report for the year ended August 31 shows that the sales of coal were 320,476 tons and of coke 102,681 tons. The revenue for the year was £309,667, and the profit was £57,595, out of which £56,733 has been paid as dividend, being at the rate of 10%. The mine was idle for 54 days, due to strikes and shortage of truck supply. Nevertheless the output showed an increase of 17% on the previous year. A strike which lasted from December 22, 1919, to January 3, 1920, was not directed against the company, but was in sympathy with strikers at other mines. The supply of native labour has greatly improved. The developed reserve is estimated at 6,015,000 tons, and the probable reserve within a two-mile radius at 54,000,000 tons. As recorded a year or more ago, it is not convenient to extend operations at the present workings, so new workings are being opened at another site, where shaft-sinking is now in progress.

Premier (Transvaal) Diamond Mining.—This company was formed in 1902 to work diamond pipes north of Pretoria. Control was obtained by Barnato Brothers in 1912, and it was transferred to the De Beers company in 1917. The report for the year ended October 31 last shows that 4,660,498 loads (16 cu. ft. each) was washed for a yield of 820,564 carats, or 0·176 carat per load. The pipe has been developed to the 460 ft. level, above which the quantity of ground available for mining is 41,000,000 loads. At this level there is no sign of any contraction of the pipe. The accounts show credits of £2,098,482 on diamond account, and working expenses £749,410. Of the profit, 60% was paid to the Union of South Africa as its share, absorbing £799,400, and £72,205 was paid as taxes. The preference shares received £100,000, being at the rate of 250%, and the deferred shares £440,000, being at the rate of 1,100%.

Champion Reef Gold Mining of India.—This company was formed in 1889 by John Taylor & Sons to acquire property in the Kolar goldfield, Mysore State, South India. From 1894 to 1905 big dividends were paid; afterward, on the ore becoming of lower grade, the rate of dividends was much lower. For the year ended September 30, 1919, no distribution was made. The report for the year ended September 30 last, now issued, shows that, owing chiefly to better conditions ruling for the sale of gold, it has been possible to resume the payment of dividends. During the year, 143,386 tons of ore was treated for a yield of 79,274 oz. of gold. The income from the sale of gold was £376,222, or about £40,000 more than par value. The working profit was £66,575, of which £16,000 was written off for depreciation and £10,000 was placed to reserve. The shareholders received £34,666, or 4d. per 2s. 6d. share, the rate being 13⅓%. The ore reserve at September 30 was estimated at 248,846 tons, a reduction of 44,669 tons as compared with the previous year. Sufficient work has not been done on the new shoot of ore on the 63rd level in Carmichael's Section to warrant a definite estimate of the ore being made. The mine continues to suffer from rock-bursts, which interfere with stoping operations. Recent bursts have caused a drop in the output, and it will be some months before the normal figures are reached once more.

Huelva Copper and Sulphur.—This company was formed in 1903 to work the Monte Romero and other pyrites mines in the south of Spain, previously worked by the Huelva Central Copper Mining Co. Under the management of Henry F. Collins, a smelting plant was erected. The company now produces smelted copper, cement copper, washed pyrites, and complex ore. The report for the year ended June 30 last shows that 66,243 tons of ore was raised, and that 5,862 tons of ore and precipitate was purchased. The output of copper was 1,649 tons, and 3,068 tons of complex ore was sold. The financial result of the year's work was a loss of £5,632. Since the end of the period under review, more favourable contracts have been made for the sale of the copper, complex ore, and washed ore. The company had great difficulty in securing coal and coke, but recently were able to make a contract for supplies with the Penarroya Company. The outlook, therefore, is now more favourable.

Rafinpa (Nigeria) Tin.—This company was formed in 1912 to acquire alluvial tin property 62 miles east of Zaria, Northern Nigeria. This property was not a success, and other properties have been acquired since. An interest has also been secured in stream deposits at Bissoe, Cornwall. The report for the year ended March 31 last shows expenditure of £7,413, of which £1,349 represented interest on loans, as against £2,469 received from the sale of tin concentrate. Since the close of the period covered by the report, the first unit of the treatment plant at Bissoe has been started, but additional plant has been necessary to improve the recovery and to save by-products.

South Bukeru (Nigeria) Tin.—This company was formed in 1910 to acquire alluvial tin property in Nigeria, and other properties have been acquired since. S. R. Bastard is chairman, and C. G. Lush is consulting engineer. The report for the year ended June 30 last shows that the output of tin concentrate was 91½ tons, as compared with 53 tons during the previous year. The sales of concentrate brought an income of £17,356, and the net profit was £95, but if it had not been for a refund of excess profits duty, £2,384, there would have been a considerable adverse balance.

Bullfinch Proprietary.—This company was formed in 1910 to acquire gold-mining property 23 miles north-east of Southern Cross, West Australia. It was reconstructed in 1919. The report for the thirteen months ended September 30 last shows that 70,250 tons of ore was raised and sent to the mill, where 15,560 oz. of gold was extracted. The par value of the gold and silver won was £67,353, to which is added £27,438 for gold premium realized. The working cost at the mine was £77,984, and £6,997 was spent in testing other properties, notably the Victory North, on Hampton Plains. The net profit for the year was £5,806, which was carried forward. A large amount of development work has been done during the period. The reserve is estimated at 50,710 tons, averaging 18s. 8d. per ton at par.

Deebook Dredging.—This company was formed in Victoria in 1913 to acquire alluvial tin properties at the northern end of Bangnon Valley, Renong, Western Siamese States. One dredge commenced work in 1914 and another twelve months later. The property not proving satisfactory, one of the dredges was sold in 1917 to the Ronpibon Extended, and in 1918 negotiations were entered into for the sale of the other dredge to the Taiping Tin Dredging Co. The report for the year ended May 31 last shows that the Ronpibon dredge extracted 282 tons of tin concentrate from 678,000 cu. yd. of ground, and that the Deebook company received £1,125 as dividend on its holding in Ronpibon Extended shares. The company has not been able to acquire any other suitable property, so the directors have decided to distribute the money received from the Taiping company in payment for the dredge as a return of capital. The first instalment of £5,000 has already been paid, and further sums will be distributed as the debt is liquidated.

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EDITORIAL

THE memorial tablet erected to the memory of members of the Mining and Metallurgical Club who fell in the war was unveiled on March 7, the ceremony being performed by Mr. Walter McDermott, who spoke a few brief but touching words.

THE appointment of Mr. H. C. Hoover as Secretary of Commerce in Mr. Harding's administration is a source of gratification to mining men in all parts of the world. His administrative and financial abilities are appreciated on this side as widely as they are in his own country, and his friends here will unite with those in America in wishing him good luck.

FEW technical societies have enjoyed such rapid and solid success as the Institute of Metals. Though only in its twelfth year, its membership is already 1,350. The Institute already has local sections at Birmingham, Sheffield, and Glasgow, and the latest move has been the formation of a London section. The council also has in view the establishment of local sections at Newcastle-on-Tyne and Swansea.

STUDIES of the behaviour of rocks under great pressure are to be instituted at the University of Wisconsin, which has been able, by means of funds supplied by Mr. W. A. Clark, the copper magnate of Butte and Arizona, to install a hydraulic press capable of exerting a pressure of 200 tons per square inch for prolonged periods of time. The press is fitted with devices for raising the temperature of the material under treatment and for measuring it. It is hoped, with this machine, to investigate many points connected with the metamorphism of rocks.

A branch of the Geological Survey of England and Wales has been established in Whitehaven, with Mr. Bernard Smith as district geologist. The re-mapping of the Cumberland and Furness iron and coal districts is to be undertaken, and investigations are also to be made in connection with lead, zinc, and copper deposits. It is to be hoped that Mr. Bernard Smith will invite the assistance of Mr. J. D. Kendall, whose knowledge of this district is unrivalled. There is one point in relation to these industrial activities of the Geological Survey that requires comment. We refer to the fact that the Survey is now in the control of the Department of Scientific and Industrial Research, a department which does not give the entire results of the researches to the public. In this case we wonder who will get the benefit of such discoveries or recommendations as may be made by Mr. Bernard Smith and his coadjutors.

LAST month reference was made to the alleged injury to marine life caused by the escape of oil-fuel from oil-burning steamers. Many of the statements on this subject are unsupported by direct evidence and are rather vague, so it is desirable to draw attention to definite and reliable pronouncements. For instance, in *Nature* for February 24, Professor Walter E. Collinge, of St. Andrews, writes to the effect that during the past five years numbers of birds which dive beneath the surface of the water in order to obtain their food have been washed up on the Fife coast and elsewhere dead or in a dying condition and covered with a thick coating of oil. In one day he counted more than three hundred kittiwakes, and almost the same number of razorbills and guillemots, and dozens of little auks and puffins.

The Wave-Transmission Rock-Drill.

Last month we published an article by Mr. P. J. Risdon explaining the principle of the wave-transmission rock-drill, and in this issue appears his second article describing the drill and the wave-generator. A general account of the drill was given in our issue of June last, so that there is little left to be said on this occasion. Some of our readers may remember that this drill was tried in South Africa between four and five years ago, and an illustrated note of the trials was made in these pages at the time. War conditions then prevented the continuation of the trials and the making of modifications suggested by the result of these trials. The application of the principle to the synchronizing of aeroplane-engine with hind gunfire took up all the attention of Mr. Constantinesco, the inventor, and Messrs. W. H. Dorman & Co., Ltd., the makers. It is only since the end of the war that attention has once more been given to the drill. In the South African tests one of the weaknesses revealed arose from the use of a spring for effecting the back stroke of the drill. In the improved drill as at present working both the back and the forward motions are obtained by the wave power. A second difficulty in the early days was to find a pipe that

could withstand the high pressures employed. The introduction of the jointed steel piping known as "flexstel" has overcome this drawback. A third problem that caused considerable trouble at first was to find some way of preventing a continuous increase of pressure when the generator was working and the drills were out of use. This source of danger has now been removed by the introduction of the vessels called "capacities" as part of the structure of the generators. Naturally the employment of such high pressures has made it necessary to use considerable thicknesses of metal in the experimental work, for it was obviously desirable to eliminate or reduce risks. Thus the drill as at present made may seem bulky, though it would not appear so by comparison with the heavy drills of a dozen years ago. With experience it will, of course, be possible to reduce the weight eventually. The drill as at present exhibited and in use is applicable for development rather than for stoping, but judging by the success of the firm's rivetters and caulking hammers there is no reason why light stopers and sinkers should not be made. As regards the structure of the drill itself, it will be seen to be extremely simple. There are no valves, and a close fit of the moving parts is not an absolute necessity. The prevention of dust is easily effected, for the water is allowed to pass down the central hole by its own pressure. As regards efficiency, the drill gives blows at a greater rate than the ordinary hammer-drill, and the actual drilling time is proportionately decreased. It is claimed by the makers that the ratio of work done to power put into the drill is much higher than when the compressed air is used. This is quite likely to be so, for only a small proportion of the power of compressed air is utilized in the drill. On the other hand, the power cannot be efficiently conducted along a great length of water pipe, so that it is out of the question to place the generator at the surface and carry the pipes down the shaft. The plan is to bring the power as near the working faces as possible by electric current and to feed anything up to ten drills from each generator. The drill has arrived at a practical stage, and is being put to work at a number of mines and quarries. It has also been shown in full work at the Efficiency Exhibition at Olympia, and it is always to be seen at Messrs. Dorman's works at Stafford.

The Excess Profits Duty.

As briefly recorded last month, the Chancellor of the Exchequer has announced that the Excess Profits Tax is to be abandoned, and for a gloomy enough reason. That is to say, the Government anticipates a severe drop in the receipts from this source owing to the serious depression in trade, and is moreover frightened that the demands for refunds will become overwhelming. The position of the Chancellor is humorously reminiscent of that of the colonel of volunteers of early days, who stentoriously gave the order "Cease firing!" when the corporal told him that the ammunition was exhausted. It is hardly necessary to say much at this juncture as to the expected relief to industry which this withdrawal of the tax will bring, for the depression is so general and the causes for it are so numerous that the removal of one of the causes will have little effect for the time being. It is true that another cause of the dullness, the high cost of living, is showing some signs of abatement. Here and there also wages are being reduced. Both of these movements, however, must go very much farther before the trade position can be appreciably affected, and, finally, the rate of work must be speeded-up enormously.

The Excess Profits Duty is one of those projects which are theoretically ideal but prove in practice to bring evil results in their wake. It was originally introduced for the purpose of equalizing war profits and war expenditure, and as such it was willingly accepted by the nation and by the war contractors. Hardly anybody realized at first that the Act as passed brought every business in the country into its net. Least of all did the mining companies, whose assets automatically deteriorate, imagine that they would be subjected to the same tax as the manufacturing companies and the producers whose assets renew themselves annually. In glancing back through the pages of the MAGAZINE in the latter part of 1915, we renew our recollection of the incredulity and the state of appal which came over the mining profession when this fact was realized. It then became clear that new mining business based on moderate capitalization was virtually doomed. It is true that, subsequently, the terms were made easier by the maximum untaxable return being raised, but this relief was grudgingly given and only to individual companies or groups of companies that brought a petition. It is not too much to say that the present parlous state of metalliferous mining is due to some extent to this penalizing of the beginner. The old mines have continued at work, and are correspondingly nearer to their end, while few new enterprises have been developed. Now that the tax is withdrawn, the effect of the relief will unfortunately be a negligible quantity, for the

prices of metals are so low and the output so difficult to sell that the complete or partial closure of operations is the order of the day and the consideration of new business is out of the question. But this depression cannot last for ever, and when better times arrive the life of the promoter and investor will be sweetened by the knowledge that profits will not be rationed.

Of the many evil results of the tax two have become notoriously conspicuous. One is the flouting of prudent policy by the abstraction on the part of the Government of the profits that should go to reserve funds. The other has been the tendency to dodge the tax by inaugurating extravagant expenditure. Both of these interferences with the strict principles of economics have had very bad influence on business methods. The aberrations from the narrow path have not only been bad for the business man himself, but the infection of his carelessness and extravagance has spread to the worker, and has had the effect of making the worker's present indifference more pronounced. The business man may be able to retrieve the position when the irritating cause is removed, but the worker, not being able to diagnose the symptoms, is not so easy to convert once more to principles of diligence and economy. It is not possible, within the bounds of a short editorial, to weigh all the constituents of the complicated problems of labour, business administration, and taxation bearing on this question of Excess Profits Duty. All that we can say is that the abolition of the tax constitutes an important step toward bringing about cheaper and more profitable operations once more, benefiting capital and labour alike.

The Imperial College's Athletic Ground.

It will be remembered that about a year ago a committee was formed representing the Royal School of Mines, the Royal College of Science, and the City & Guilds College, which are the constituent schools of the Imperial College of Science and Technology, for the purpose of inaugurating a War Memorial. Wisely, the idea of an elaborate structure in stone or bronze was ruled out at the beginning, and it was decided that the records of the men who had fallen in the war should be inscribed on simple tablets to be placed in each of the schools; thus the funds to be subscribed would be available for a more permanently useful memorial, one which would help in the inculcation of an esprit de corps, and at the same time cultivate hardihood, personal daring, and ability to command and obey. South Kensington has for long enough been short in opportunities for athletic exercise, though it is clear that bodily fitness should form part of the equipment of an engineer. The appropriateness of recording war services by doing something to remove this anomaly was therefore obvious, and the committee had no hesitation in embarking on a scheme commensurate with the dignity of the Imperial College. After many inquiries and investigations had been made, a suitable site for the grounds, comprising 23 acres, was discovered between Wembley and Harrow. This district is a well-known habitat for Sports Clubs of all kinds. The Harrow School playing fields are nearby. University College School has it grounds the other side of Wembley. There are numerous first-rate golf clubs within easy reach. Moreover, a number of big business houses have established sports grounds for their employees at various points along the railways that intersect the district. The one drawback is the distance of the ground from the College, but this is a drawback that is unfortunately unavoidable in London. Those who have cars or motor-bikes will not complain of the journeys to and fro, but, it cannot be denied, those who go by train or tram will find the travel tedious. The grounds are most easily accessible from North Wembley station on the Bakerloo line, and the nearest station to the College is across Hyde Park at Paddington. Sudbury Town station on the District Railway is about a mile away from the grounds, and the trains serving this station come from South Kensington by way of Ealing. The grounds can also be reached from Preston Road station on the Metropolitan, and from Sudbury station on the Great Central, though there are very few trains on the latter line. An alternative route is by tram from Edgware Road and Paddington, along the Harrow Road to the Sudbury terminus at the junction of the upper and lower roads to Harrow. Considering London conditions generally, the position of the ground is perhaps not so very inconvenient as it might appear at first sight.

The committee estimated that the total cost would amount to £12,000, the actual price of the freehold of the 23 acres of ground being £7,500. A three months' option was obtained, and a campaign for raising funds was at once commenced. The response was sufficiently encouraging to warrant the committee completing the purchase, by the help of a bank advance on security of a mortgage. It has been possible during the winter to use part of

Map showing position of the Imperial College Athletic Grounds

the ground for football purposes, but funds are required for putting the fields into condition for other sports, and a suitable pavilion is still wanted. In addition it is necessary to pay off the overdraft from the bank. The actual position at the end of 1920 was that £7,000 had been subscribed, while £2,000 had been borrowed. On behalf of the committee we take this opportunity of appealing to all Associates of the Royal School of Mines to send contributions. Those who have not yet responded are asked to give liberally, and those who have already sent something to send a little more. City men who prize technical and administrative ability at the mines and works they control are also encouraged to help in completing the endowment of this necessary phase of engineering education, this branch of education which makes managers and not dreamers.

Deep Shafts.

The paper discussed at the February meeting of the Institution of Mining and Metallurgy put in a concise form the main problems involved in mining at great depths. In this paper Mr. E. H. Clifford gave particulars of the new vertical shaft now being sunk at City Deep for the purpose of attacking ground down to 7,000 ft. In the Mining Digest we reproduce the first part of the paper, dealing with the mechanical details of the shaft, but we have omitted the second part, in which the theory of the ventilation of deep and hot mines is discussed, for the reason that there has been much in the MAGAZINE recently on this branch of the subject. In the first place, Mr. Clifford's account of the ventilation problem at City Deep was given in our issue of September, 1919, and a paper on the problem at St. John del Rey, written by Mr. Eric Davis, was published in the issue of October, 1919. Then the whole subject of ventilation of deep mines was treated by Mr. David Penman in an article in June, 1920. The physiological conditions as induced by heat, cold, moisture, and air currents have been very fully studied by Dr. Leonard Hill, a distinguished London physician, and his writings should be in the hands of all mining engineers interested in ventilation. In particular should be mentioned his reports on the science of ventilation written for the Medical Research Committee and published by the National Health Insurance organization. His modified hygrometer, called the kata-thermometer, has been designed to indicate the cooling effect due to the motion of the air, and thereby to test the physical efficiency of a ventilating current. As regards the general question of cooling by the introduction of dried air, there is one special feature of mining on the Rand that has to be considered; that is to say, if the current is too rapid the natives are likely to be attacked by pneumonia, so there is a very definite limit to

the amount of air-motion allowable. On the other hand, the mines on the Rand are at a great advantage over mines in many other districts. For instance, a large proportion of them are dry, and the incoming air is also dry. Also the rise of temperature with depth is comparatively slow, so that the rock temperature at 7,000 ft. is not likely to be much more than 95°F. The other items deciding the feasibility of deep mining are the amount of pumping necessary, and the ability of the walls to stand the strain due to the weight of the overlying strata. In both cases the conditions at City Deep, and indeed on the Rand generally, are favourable. It is true that in some sections of the Rand the incoming water is large, but these wet mines are mostly in the Far East basin, where mining in depth is not to be considered in the same light as at City Deep, Crown Mines, or other properties in the central Rand.

There are a number of points in Mr. Clifford's description of the new shaft that are of interest. In the first place, he indicates the limit of hoisting from depth in a vertical shaft. A consideration of ruling conditions showed the engineers that 4,500 ft. should be the maximum depth for a single hoist. The only doubt that existed was as to whether the hoisting from 7,000 ft. should not be divided into two equal hoists of 3,500 ft. each, but the point was decided by the fact that the electric winders which were to be installed underground for the lower lift would give out a great amount of heat, and that the ventilation problem would be complicated accordingly. It is often forgotten by engineers that electric motors give out heat proportional to the difference between the total electrical input of the winder and the net work of raising the load. This is an important point in connection with electrical engineering, and mining men and others who have an idea that electrical machinery is entirely self-contained in its influence and action should make note of this circumstance. In many cases, of course, the disadvantage has been overcome by the use of hoists driven by compressed air. At the City Deep new shaft it was found desirable to have the first lift as deep as possible, so that the underground electric winder should be of the minimum size possible. Even then the electrical winders for the lower 2,500 ft. are found to require a ventilating current of 75,000 cu. ft. per minute, or practically one quarter of the total amount of air sent under-ground. The ventilation problem for deep mining is therefore complicated by the necessity for having double lifts.

A second point of interest in the City Deep equipment is that skips are not used, but that double-deck cages are employed, the lower deck accommodating an 8 ton ore car, and both decks being adapted for a hundred men being carried on each trip. Each cage measures 15 ft. 6 in. by 5 ft. 3 in. Instead of there being a divider between the track of the two cages, two so-called dividers are placed one on each side of the shaft, and guide rails are employed instead of guide ropes. It will be seen from the illustrations accompanying the paper that the area of the shaft is put to good advantage. The only other vertical shaft which has been described in our pages is that sunk at the Champion Reef of India, particulars of which were given in the issue of January, 1912. By reference to the drawing then given, it will be seen that there are two cages on one side of the central divider and two skips on the other side, both skips and cages being held in position by guide rails. As regards the discussion as to the advantages of circular shafts as compared with rectangular shafts on the Rand, nothing need be said here, as the question was fully discussed in papers quoted in the MAGAZINE for April and May, 1919. In this discussion it was made manifest that the engineers of the Central Mining group were strongly in favour of the vertical shaft. One of the points in the City Deep design that wants some further explanation is the arrangement of the upper and lower shaft so close together in the vertical line. The idea was no doubt to reduce the lateral movement of the cars at the intermediate station to a minimum, but a number of speakers at the meeting expressed the view that some method more economical in power than the traverser should be employed, and that it would be better to have the shafts farther apart so as to afford leeway in case of any hitch in connection of the machinery of either shaft. For ourselves we do not think that this point is of as great importance as the critics suggested, but Mr. Clifford's reply, giving details on which the decision to adopt this system was based, will be of considerable interest. There is one question which we should like to put to Mr. Clifford: Why does he call Holman sinking drills Leyners? We had an idea that Leyners were made by the Ingersoll-Rand Company. Whether the latter company or Holman Brothers, or either of them, will feel flattered by this mixture of terms we are not prepared to say. In the interests of precision of nomenclature we consider that the word "Leyner" should be a trade mark of the makers of the Leyner drill.

REVIEW OF MINING

Introduction.—The tendency toward lower prices for food and clothing and also toward lower wages is growing more marked. Coal mining and the railways are being released from Government control, and the wages question will be immediately tackled. In spite of the present severe depression in trade, there is a general impression that, as there is an obvious cure, the outlook is not really bad. In metal and mining circles the curtailment of production and the low prices have caused many hardships, but the belief is gaining ground that an approaching lowering of wages and costs and a renewing of demand will restore normal conditions. There is certainly a revival of interest in new mining properties. The political situation with regard to Germany has arrived at another state of crisis, and the severance of negotiations with regard to reparations and the decision of the Allies to occupy certain German towns indicate a stiffening of policy which will be all for the best.

Transvaal.—The triumph of General Smuts at the recent general election has had a steadying effect in business and political circles, and the controllers of the gold mines in particular feel a substantial accession of confidence.

The strike which broke out at Consolidated Langlaagte just before the General Election and spread rapidly among workers at other mines did not last long, for the men's unions were against a general strike and also condemned the precipitate action at Langlaagte. It is settled that the present rate of wages shall continue until the end of the year.

The exploratory work that is being done in the Bantjes property by the Consolidated Main Reef company is giving disappointing results. It will be remembered that this work was done with the object of testing Bantjes ground at a considerably greater depth than the present lowest levels. An exploratory drift in the Consolidated Main Reef ground was carried into the Bantjes, and the intention was to continue it for 3,500 ft. to a point a distance of three levels under the Bantjes incline shaft. About 1,500 ft. has been driven so far, and it is intended to continue for another 500 ft. in hopes of something valuable being found. If the results continue unfavourable, the directors will propose the liquidation of the Bantjes company. During the past month there were rumours that Consolidated Main Reef was intending to absorb Bantjes, but such a scheme would be quite out of the question.

The ore reserves at Modderfontein Deep, as calculated at the end of December last, show a gratifying increase. The figures are 4,100,000 tons averaging 9·4 dwt. over 77 in.; these compare with 3,775,000 tons averaging 9·1 dwt. over the same width at the end of 1919. As recorded last month, the other Far East Rand property of the Union Corporation group, the Geduld, shows a similar improvement.

The Daggafontein mine has had to close down owing to the continued want of success in development and to the exhaustion of working capital. This event was not unexpected by those who had followed development reports, but nevertheless it has given a nasty jar to the mining market. It is only eighteen months since the property was defined, according to the system devised by the Transvaal Government. Reference to a map in our issue of August, 1919, will show that the property consists of 2,059 claims to the east of Springs and south of the Cassel-Clydesdale. One cause of the trouble has been the faulting by dykes, which occurs to a greater extent than is usual in the Far East Rand. As regards finance, the Consolidated Mines Selection Company, on the reorganization in 1916, subscribed £300,000 by the purchase of 300,000 shares at par, and subsequently took £115,874 shares at par. In 1919 the company advanced £250,000 on loan and a further £100,000 was lent last year. The question at the present juncture was whether the loans should be increased, the finances reorganized, or the work suspended until a time arrives when additional funds can be raised under more auspicious conditions. The policy adopted is to let things lie quiet for a while until more geological evidence is obtained in the adjoining Springs workings.

The Consolidated Mines Selection Company has declared its dividend for 1920 at the rate of 1s. 6d. per 10s. share. This compares with 3s. 6d. for 1919 and 3s. for each of the two preceding years. In spite of the fall in the rate, the result can be considered quite good, when the general depression in the Rand market during the past year is considered. In fact in some quarters it was believed that there would be no distribution at all. The company has done notable work in financing Brakpan, Springs, West Springs, and Daggafontein. In all probability it will have to find further funds for the last named.

The liquidators of Village Main Reef have announced a first distribution amounting to

£157,000, being at the rate of 6s. 8d. per share. It is officially estimated that a further 3s. 4d. will be available for distribution.

Two of the old Barnato companies that went into liquidation recently have announced their first distribution of assets. Glencairn is paying 2s. per share and Ginsberg 5s. per share.

One of the depressing elements in the market for South African gold-mining shares has been the uncertainty as to the disposal of enemy shareholdings. The terms of sale offered by the Custodian in South Africa and the Trustee in England were not acceptable to the finance houses, and also they to some extent clashed with each other. These difficulties are now under consideration by the authorities, and as the South African Custodian is in London, conferring with the Trustee and others, some comprehensive and satisfactory scheme for the sale of these shares will no doubt be evolved.

The appeal of Sir J. B. Robinson against the award of the lower court in the Randfontein Estates case has been dismissed, and he will have to pay £460,000. This would be a large sum in ordinary transactions, but the Randfontein Estates is a big finance company, and has lent more than this amount to the Randfontein Central. Nevertheless, the money will be acceptable, seeing that the reorganization of the latter company's mine has cost so much money.

Diamonds.—The depression in the market for the sale of diamonds is becoming more accentuated, and the steps taken by the mines, as reported last month, to prevent over-production are proving by no means sufficient to meet the position. At the Premier mine the work had already been reduced from three to two shifts per day, but news is now to hand that a further curtailment has taken place. Only one shift per day is now being worked. At the De Beers group it has been found necessary to close the Wesselton mine for a time. This closure involves the dismissal of five hundred white employees. The companies, in dismissing the white employees, give them bonuses of £100 each.

The Frank Smith diamond mines are to be closed down, owing as much to the want of success that has attended operations since the re-opening some months ago as to the slackness in the diamond trade. The funds recently subscribed are exhausted, and the present is not the time for raising more capital; otherwise the directors would have tested other parts of the ground. Possibly, when conditions improve, this latter policy will be adopted.

Congo State.—Reference has been made many times in the MAGAZINE to the fact that the river Congo is of little use in navigation owing to shallows and rapids. The Belgian Government recently established an air-way along the river from Kinshasa to Stanleyville for the transport of passengers and goods. One of the difficulties was to provide landing places along the route and to afford relief to aeroplanes that might have to land on account of engine troubles. Many parts of the country are so isolated and the communications so bad that an aeroplane making a forced landing might be irrevocably lost. The plan adopted is to send two or more aeroplanes together, so that if one of them fails the others can notify the fact and bring relief. It is hoped eventually to establish wireless-telephone stations able to communicate with each aeroplane. This service of aeroplanes will eventually be of great service in the prospecting of the Congo State and the regions behind.

Rhodesia.—The output of gold during January was returned at 46,956 oz., and the value at £293,784. As the value per ounce works out at £6. 5s., it is clear that the authorities are not yet able to fix even approximately the premium receivable for each month's production and that the figure for January includes some accumulation of premiums. The other outputs for the month in Southern Rhodesia were: Silver 12,529 oz., copper 240 tons, arsenic 34 tons, tin 3 tons, coal 54,534 tons, chrome ore 5,285 tons, asbestos 2,501 tons, mica 14 tons, diamonds 23 carats.

The labour trouble at the Rhodesian mines has at last been brought to a definite head by the firm attitude of the Mine Owners' Association. For a long time the men's unions have been squeezing the companies one by one, and when each had agreed to new terms the unions commenced another circuit of the mines. On this occasion the trouble started at Shamva, when the men came out on February 19. At the Wankie Collieries trouble arose with regard to the employment of non-union men. Eventually the Mine Owners' Association gave notice of a general policy of lock-out. Already the Lonely Reef has been closed down.

West Africa.—At the meeting of the Taquah Central Mines, the chairman, Mr. T. F. Dalglish, was able to give a much more hopeful account of the labour position in West Africa as affecting the gold-mining industry than he could when presiding at the Taquah and Abosso meetings two months earlier. The Governor of the Gold Coast and the Colonial Office at home have listened to representations, and steps are being taken to meet the gold industry's requirements. Mr. Dalglish's group, in combina-

tion with the Ashanti Goldfields, are devising a scheme, with the consent and assistance of the Government, for recruiting in the northern territories, and a recruiting officer is being appointed who will be fully accredited by the Gold Coast Government. One of the competitors for labour, the cocoa industry, is tending to slacken, and this fact will also benefit the gold mines.

Nigeria.—The collapse of the British West African Trading Company is a matter of regret, not only to the shareholders but to all interested in the prosperity of British trade with Nigeria and the Gold Coast. The company was until a few months ago known as the Tin Areas of Nigeria. Founded on the tin industry, it gradually extended its interests, and there was every prospect of it becoming a sound trading concern. The slump in Nigerian products caused financial difficulties, and an attempt was made to provide further funds by offering debentures in October last. In December a member of a firm of chartered accountants was made receiver and manager, and on February 23 an order was made by the Court for the compulsory winding up of the company. It is believed that not only will the shareholders get nothing but that the debenture holders will not be paid off in full.

Australia.—The position of the Broken Hill mines continues to be serious, owing partly to the low price of metals and partly to the fire at the Port Pirie smelting works. As regards the lead-smelting question, the Sulphide Corporation has undertaken to treat 600 tons of concentrates weekly from the other mines at Broken Hill, making with its own concentrates from the Central mine a treatment of 1,100 tons weekly. In addition the mines will produce 400 tons weekly to be exported for smelting in Europe. It is not believed that any profit will be made by this scheme of operations, and it is only to hold good for two months or so, after which the future policy will have to be decided according to conditions then current. At Port Pirie a temporary roasting plant is to be erected capable of treating 2,000 tons of concentrates weekly, but the cost of roasting will be greater with this plant than at the plant that was destroyed by fire, so it is doubtful to what extent it will be eventually of value in easing the position.

The Broken Hill Proprietary has had trouble at its iron and steel works as well as at Broken Hill. Owing to the shipping strike communication between the smelter and steel works at Newcastle, New South Wales, and the iron ore deposits in South Australia was suspended. The result was that the furnaces went out of blast and subsequently the steel works stopped. Later cables announce that the seamen's strike has been settled, and that the steamers have commenced to run again. Still later cables state that the strike of the men at the company's iron mines has also been settled, so that the position is once more clear.

The Queensland Government is contemplating the building of a railway from Croydon eastward to Georgetown and Forsayth in the Etheridge goldfield, thus connecting the railway starting from the Gulf of Carpentaria with the railways coming westward from Cairns and serving the Chillagoe and the tin districts. The idea is that such a railway would help the Etheridge goldfield, which is now practically deserted. The Einasleigh copper mine, in the Etheridge district, was once well known in London. As regards the building of this new railway, the doubtful question is whether the Government can raise the capital. To put forward such a project at the present time when there has been a hitch in the payment of debenture interest and in the redemption of debentures of the Chillagoe Company does not seem good politics.

New Zealand.—Last month we announced that the Waihi Gold Mining Company was contemplating the return of £250,000 capital in cash and the concurrent reduction of the £1 shares to a denomination of 10s. Notices have now been issued for the holding of the necessary meeting on March 17 for the purpose of obtaining the consent of shareholders prior to the scheme going before the Court for its sanction.

India.—The Mysore Gold Mining Company announces a final dividend for 1920 amounting to 1s. 3d. per 10s. share, together with a bonus of 6d. per share. The total distribution for 1920 is therefore 2s. 6d. per share. In comparing this distribution with those of recent previous years, it has to be remembered that the capital was doubled a year ago, when 610,000 new shares of 10s. were subscribed at par by the shareholders for the purpose of embarking on a comprehensive scheme of development in depth. Thus the 2s. 6d. for 1920, when compared with the 2s. for 1919, represents a correspondingly greater profit. This increase is partly due to various items of cost being covered by the new capital instead of being provided out of revenue; but it is chiefly due to the more favourable terms obtained by the company as regards the disposal of the gold produced.

Malaya.—In January the Federated Malay States Government undertook to buy tin at a

price corresponding to £236 delivered in this country, in order to sustain the local industry. In the middle of February this price was reduced to the equivalent of £204. At the end of February the "peg" was withdrawn altogether, an action which indicates that the Government considers drastic restriction of output the only possible remedy for the present lamentable condition of the tin market.

Cornwall.—The position of the tin-mining industry continues to cause anxiety throughout the county. The men out of work are not able to find other occupations and have to subsist on the doles. The mines owned by public companies have all closed down, and the only question is whether all of them will be able to stand the heavy cost of pumping necessary to keep the workings clear. The Geevor mine is in a particularly unfortunate position owing to shortness of funds. The cause of this arises from the inability of certain shareholders, both individuals and finance companies, to meet the calls due on the new shares issued at the end of 1919. The present position is that the company is £15,000 in debt, and a sum of £5,000 is also required wherewith to continue pumping and to keep the plant in repair. In order to raise these funds, the directors have decided to offer pro rata to shareholders £25,000 8% tax-free debentures redeemable in two years at par. The shareholders who have not been able to pay their calls have agreed to hand over sufficient fully-paid Geevor shares to give a bonus of 25 of these shares to every subscriber of £100 debentures.

The report of East Pool & Agar shows a loss of £19,421, or when depreciation, etc., is allowed, £28,007. This position is entirely due to the fall in the price of tin, arsenic, and wolfram, and the increase in the cost of coal, materials, and labour. The mine has never looked better, and new discoveries of high-grade ore have added substantially to the reserves. The outputs for the year were: tin concentrate 874 tons, wolfram 46 tons, and arsenic 500 tons. As recorded last month, mining was suspended on February 12 until conditions improve.

Canada.—The nickel industry of Canada is suffering owing to the lack of demand for the metal following on the slackening of naval and military construction work. The mines of the British American Nickel Corporation at Sudbury have been shut down. The smelter has also been closed, and the refinery will be closed when the matte in hand has been treated. At the Mond Nickel Company's mines and smelter the men have agreed to a reduction of wages averaging 40 cents per day.

Owing to the low price of silver the Mining Corporation of Canada has closed down its mines at Cobalt. The Kirkland Lake Proprietary reports the discovery of high-grade ore at its Cobalt property, and also promises to issue a report on the Kirkland Lake properties.

Mexico.—The speech of Mr. R. T. Bayliss at the meeting of the Exploration Company contained much that was cheerful with regard to the future of Mexico. He considers that the position in that country has vastly improved during the past year, though there still remains much to be done for improving its economic and industrial stability. He believes that the large public revenue accruing from the export of oil will in itself be sufficient to re-establish the finances on a sound basis, and that this revenue will amply make good the losses due to the fall in the price of silver and the reduced outputs of silver, gold, copper, and lead. As to the fall in silver and the consequent closing of many mines, he sees in this the economic opportunity for bringing wages down once more to a reasonable level. Taking things altogether he considers the outlook hopeful, and feels encouraged to increase the company's interests in Mexican mines whenever reasonable proposals are put before him.

Peru.—Another attempt is to be made to put the San Antonio de Esquilache Mines, Ltd., on its feet again. The present company was formed in 1914 to take over the properties, and under the management of the late Mr. Sydney A. R. Skertchly a large amount of new development was done. The mines are near Puno, and have been producers of silver and lead. The celebrated Caylloma silver mine is in the same district. Mr. Skertchly had not completed his scheme of development before the funds were exhausted, and his death complicated matters. The directors invited the help of Mr. G. R. Bonnard with a view of raising further funds. The present times are not favourable for schemes of this sort, and the proposals put forward by Mr. Bonnard are naturally somewhat onerous, though if all shareholders take their part in the scheme their position will be right enough. The proposal is that £20,000 additional capital shall be raised by the issue of 10% cumulative preference shares, which shall have the right to a cash bonus of £40,000 out of the first profits of the company; alternatively notes might be issued instead of preference shares, carrying the same interest and bonus. This proposal is now being considered by the board and principal shareholders. The latest news from the mine is that a silver-lead orebody has been struck in the long adit.

THE TRANSMISSION OF POWER BY WAVES.

By P. J. RISDON.

(Concluded from the February issue, page 79)

Particulars are given in this article of the new method of transmitting power by wave motion, invented by G. Constantinesco and developed by W. H. Dorman & Co., Ltd. Particular reference is made to the application of the system to the driving of rock-drills.

LAST month I gave an outline of the principle of transmission of power by waves. In the present article I will describe the application of this principle and give details of the construction of the several machines.

THE WAVE GENERATOR.—In a typical 10 h.p. plant (Figs. 6 and 7) the wave generator is mounted upon the same bedplate as the electric motor for driving it. The bedplate is cast in the form of a pair of tanks, one for holding water and the other oil, and may be arranged for bolting to a concrete foundation or for mounting upon two pairs of wheels and axles. If required the plant can be made self-propelling. Upon the bedplate is bolted the generator crank-case, also of cast iron, which accommodates the crankshaft bearings and cross-head guides. The top of the crank-case is provided with an inspection cover which serves as a ventilator and comprises an anti-splash plate. The steel crankshaft runs in phosphor bronze bearings, registered in housings integral with the crank-case. There are two cranks opposed at an angle of 180°. Each crank works a connecting rod, cross-head, and plunger or wave-power ram. On each side of the crank-case is a spherical water chamber known as a "capacity." The outer ends of the plungers, which are fitted with special U-shaped packing rings, enter the "capacities"; the other ends are enlarged and work in the cross-head guides. The plunger has a stroke of 29/32 in., and a diameter of slightly more than $1\frac{9}{16}$ in. The two "capacities" are connected by an overhead pipe, at

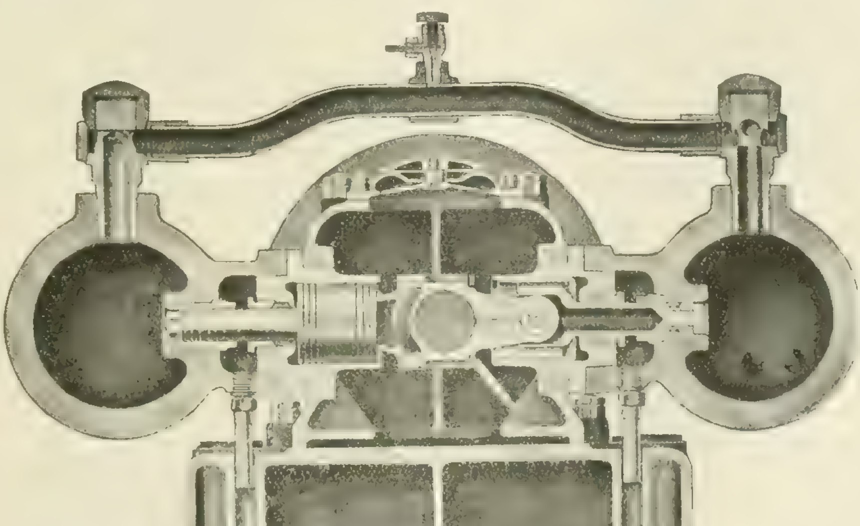


FIG. 6. SECTION OF GENERATOR THROUGH THE "CAPACITIES"

the highest point in which is an air-release needle valve, opened and closed by hand. From each of these "capacities" one or more pipes are led to the machines to be served.

At the forward end of the generator are the oil and water pumps operated by worm gearing. The former provide forced-feed lubrication of all working parts. The water pump is regulated by a pressure-difference valve fitted to one of the "capacities" so as to maintain a constant water supply at a minimum pressure of 100 lb. per sq. in. through the system, even although there may be a leakage or water may be led off to rock-drills. When the minimum pressure in the "capacity" is greater than the pump pressure, the valve is closed, but immediately it falls below that of the pump it opens. This water pump must not be confused with the wave-power plungers or rams, driven by the crankshaft, which set up the wave impulses. A heavy steel flywheel is mounted on the crankshaft between the power unit and the generator.

The generator is so free from vibration that, when at work, a coin can be balanced edgewise upon it. It may be driven by any convenient and efficient means, such as an electric motor or by a steam, oil, or petrol engine. Even belt driving is permissible, but direct-coupled drive without intermediate gearing is preferable when a power-unit capable of the exact requisite speed is available.

It is not necessary to have closer governing than 5% when the transmission line is short, that is, up to about 300 ft., but with longer pipe-lines it is advisable to have the speed of the generator more constant; this, however, automatically adjusts itself within limits. The dimensions and weight of a wave generator compared with those of an air-compressor set, for a given power output, are in the ratio of about 1 to 6 in favour of the wave generator. Two or more generators can be run in parallel, supplying power to the same pipe-line.

Supposing the "capacities" and pipe-lines to be empty, the method of charging is to admit water, which has been properly strained to rid it of loose matter, to the system, by gravity if possible. The generator is started up and the water pump compresses the water to an initial pressure of 100 lb. per sq. in. The air-release valve is then opened to release air from the system, which would otherwise create surges and fluctuating pressures and greatly reduce the efficiency. The air-release valve is then closed again, and thereafter the generator continues to work automatically until further orders. Generators such as that described have been in constant use for experimental and demonstration purposes in Messrs. Dorman's works for several years, during which time it is stated that they have proved the efficiency and economy claimed for them by the makers.

MEANS OF TRANSMISSION. Ten horse-power waves are transmitted through 1 in. piping for a distance of 240 ft. But there is no theoretical limit to the length of transmission. The longer the distance the greater the diameter of pipe necessary, and the practical economic limit is only reached when the initial cost of the pipe-line and the drop in efficiency compare unfavourably with the corresponding items in electrical transmission. But although pipe-lines miles in length are practical propositions, the system accommodates itself to short distance transmission as well, so that a generator and wave motor may form integral portions of a self-contained machine, such as the portable rivetter made on this system.

Although long pipe-lines require to be laid underground or to be otherwise protected against frost in winter time, it is an interesting fact that so long as waves are passing, the water in a pipe-line cannot freeze. Indeed, supposing a main to have frozen up except for a small core of water, waves passed through the system will soon melt the ice. At first it might be supposed that, since ice in the system can be melted and heat is obviously generated, there must be heat losses. But that is not so. Heat generated is absorbed in the act of expansion at the tool end, so that in point of fact after a plant has been at work for an indefinite period, the pipes are quite cold.

From what was said last month, it might not unreasonably be assumed that every wave motor must necessarily be inserted at an exact wave or half-wave length from the generator in order to secure maximum efficiency. Although in ordinary field plants there would be no difficulty about this, in the cases of factories and workshops it would clearly entail inconvenient odd lengths of piping for individual motors in order to bring them to within multiples of half-wave lengths from the generator. This is overcome by a device called a condenser, comprising a small cylinder, of larger diameter than the pipe main, which may be inserted at any point. In this cylinder is a floating piston which is normally maintained in a central position by a spring on either side. From the cylinder a branch is led to a wave motor which it is desired to operate. Struck by the power wave on one side, the piston passes on the impulses to the water on the other side of it. But the cylinder serves as a "capacity,"

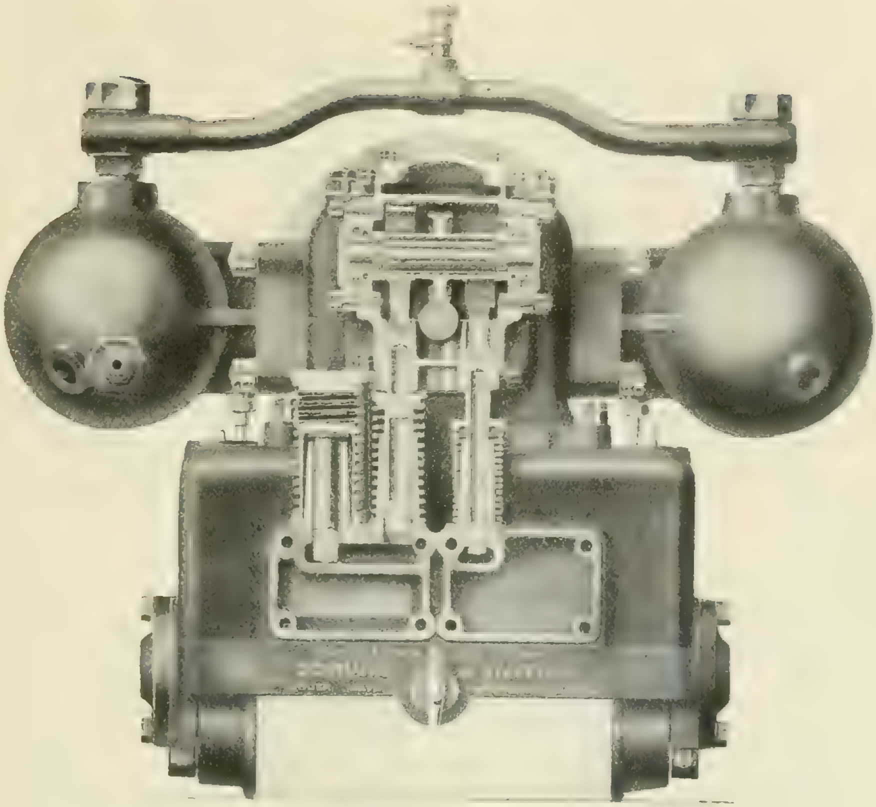


FIG. 7. SECTION OF THE GENERATOR THROUGH THE PUMP GEAR BOX

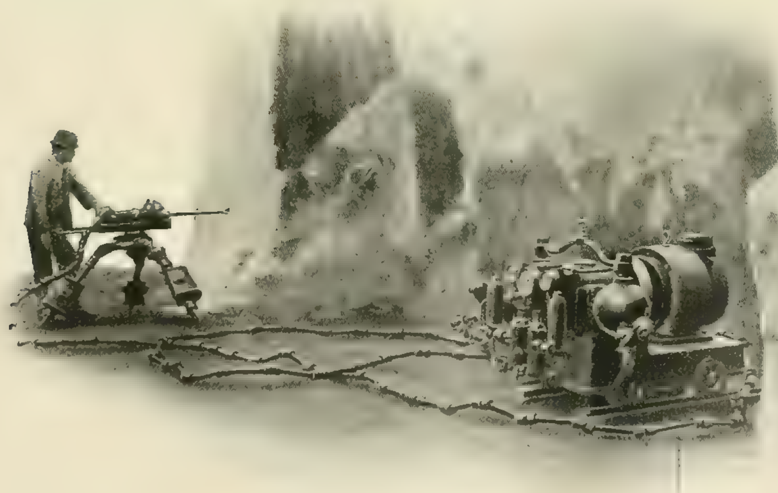


FIG. 8. THE GENERATOR, TRANSMISSION PIPES, AND ROCK-DRILL.

causing a transformation in phase and pressure of the waves. Simple as is the principle involved, each condenser has of course to be carefully proportioned for its particular function.

In motors for percussive tools such as rock-drills the monophase system is obviously the best, as will be explained later. But where it is required to utilize wave power in rotary motors the three-phase system presents distinct advantages, as for example in starting up a motor. This will be instantly appreciated by the electrical engineer, who will also best appreciate the fact that wave-power transmission bears a remarkable resemblance to electrical transmission of power. Indeed so similar are the two systems that there is no expression used in connection with alternating-current appliances which has not its counterpart in wave-power transmission parlance.

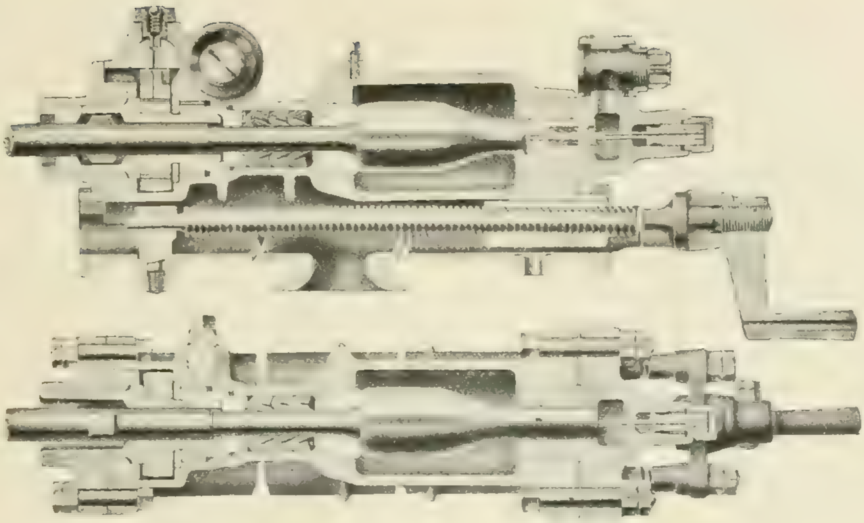
The wave velocity is 4,800 feet per second, the same as the speed of sound in water. This velocity, divided by the number of generator revolutions per second, gives the wave length. Thus with a speed of 2,400 revolutions per minute, $4{,}800 \div (2{,}400 \div 60) = 120$ ft., which is the wave length.

The pipe mains may consist of ordinary hydraulic piping, which, however, has to be rigidly anchored at intervals to minimize vibration. From the mains, "flextel" piping with flexible joints branches to the machines. There is no reason why the pipes should deteriorate in consequence of the waves passing through them, if they are of suitable section and the material is not stressed beyond its elastic limit. Messrs. Dorman have had pipes in constant daily use for the past three years, and state that they have never had a case where a pipe has given out owing to fatigue. All joints are conical and metal to metal, entirely dispensing with all packing materials. The joints can be broken and re-made any number of times without a sign of leakage.

The maximum wave pressure in a typical 10 h.p. installation is 1,500 lb. per sq. in., the mean pressure being 750 lb. In the unlikely event of a burst there is no danger whatever to be apprehended. Higher or lower pressures can be adopted in wave-transmission. The higher the pressure adopted for a given diameter of pipe, the greater is the power that can be transmitted and the higher the efficiency. The conditions for best efficiency in a pipe-line are large diameter of pipes, high pressure, and high frequency; the length of pipe-line must be a multiple of half-wave lengths; the diameter of pipe can be reduced as power is taken off at various points; it is not necessary to provide Y junctions for branch lines, square tees being equally efficient.

WAVE MOTORS.—We have now to consider the conversion of power waves into useful work. As already indicated, the waves could be made to operate a rotary motor by direct impact, but the necessity for self-starting motors renders the direct or monophase system unsuitable for the purpose. Monophase waves are therefore converted into a three-phase system, so that self-starting rotary motors of the three-phase or collector type may be employed. The rotary motors as manufactured by Messrs. Dorman are of simple construction. They may be either synchronous or asynchronous. They are self-starting. The starting torque can be greater than the driving torque. With asynchronous motors it will be equal to or but slightly less than driving torque, but with synchronous motors the starting torque will be low. The power input to the generator is proportional to the work done by the motors, so that if two or three motors in a system are cut out, the power input to the generator is proportionately reduced. If the wave power is not being absorbed by the motor, waves are reflected back to the generator and give up their energy to the generator, thereby reducing the power necessary to drive it. Synchronous motors essentially work at constant speed, and in the case of these machines variable speed of the driven shaft can only be obtained by gearing or slipping devices external to the motor. Asynchronous motors work with a slip, that is, run at a speed slightly less than synchronous speed; loading increases the slip and decreases the efficiency in proportion to the slip. The starting torque with these motors is much larger than with synchronous machines. These motors correspond to the electrical squirrel-cage motors, in which variable speed cannot be obtained without loss of power.

Collector motors are another type which have a maximum torque at starting which will be five times the running torque with machines designed to run at approximately twice the synchronous speed. Variable speed can be obtained most favourably with this type. The single-phase system can be adapted to working rotary motors in several ways: (1) By monophase displacement motor, (2) by ratchet motor, (3) by dividing up the last wave length into three parts and using a three-phase rotary motor. The single-phase system is best for driving resonators, percussive tools, and for long-distance transmission. The three-phase system is best for rotary motors. A static phase converter can be used for converting from



Figs. 9 and 10. Sections through the Rock-Drill.

single-phase to polyphase at any point in the system and is a very simple device.

The best frequency for a particular case is determined largely by the class of work that has to be done. As an example, assume a plant consisting of a single line driving a rock-drill, the most suitable speed is determined by the quality of drill steels in use, and the grade of rock to be drilled. In practice this has been found to be 40 to 50 cycles per second, giving 2,400 to 3,000 blows per minute.

The frequency of the generator is not dependent on the natural speed of the prime mover used, as obviously this can be adjusted by interposing suitable speed reducers or gearing. In practice it is advisable to avoid intermediate gear, so that every effort is made to obtain a prime mover of the desired frequency. The length of pipe plays no part at all in determining the frequency.

Figs. 9 and 10 show a rock-drill in which both the percussive and rotary motions are effected by the same monophase waves, so that absolutely perfect synchronization is ensured although a separate motor is provided for each of the two motions. One end of the hammer works in a bearing and ends in a small chamber filled with water and communicating with the pipe-line. The striking end of the hammer, of smaller diameter, also works in a guide with

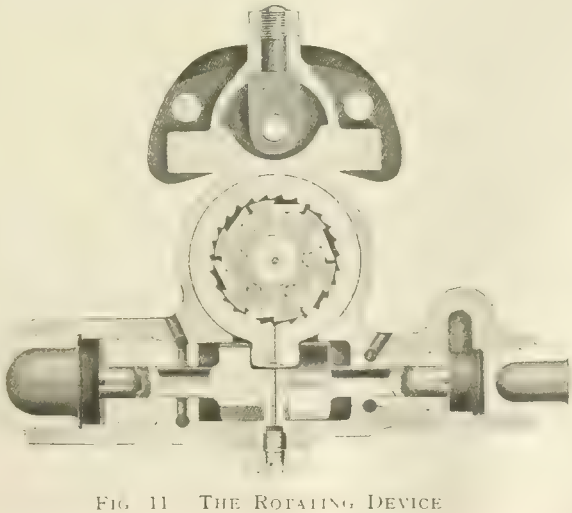


Fig. 11 The Rotating Device

U packings. The body of the hammer is enlarged in diameter and is enclosed in a chamber filled with water. A stop cock, operated by hand from outside, admits power waves, which drive the hammer forward against the end of the drill shank. In thus moving, the striking end of the hammer passes out of the chamber, while the larger end, entering the chamber, compresses the water therein. The result is that the instant the wave impact is ended, the water in the chamber, acting under compression like a spring, drives the hammer back again ready for the next power wave.

At the forward end is a rotating chuck for gripping the end of the drill shank (see Fig. 11). The chuck is fitted with six pawls which engage a circular ratchet, working in a guide, formed by an extension of the main body casting. The ratchet is formed with a lug which is engaged by a slotted plunger, the ends of which work in guides communicating with water chambers. Power waves, admitted at one end, drive the plunger forward, causing a partial turn of the ratchet chuck and drill. Water at the other end of the plunger is compressed and, acting as a spring, drives the plunger back again ready for the next wave. It will be seen that the only springs are the six small pawl springs; otherwise the drill and all its parts are of simple and solid construction, fool-proof and extremely unlikely to get out of order, as there are no finely-fitting parts. A tube passes right through the hammer from a small water chamber at the back end of the machine, and enters the shank of the hollow drill steel about 2½ to 3 in. Through this tube water is forced from the wave power main, the quantity being regulated by a valve.

The perfectly synchronous action of the two wave motors combined with their independent operation is a feature of great importance, as mining engineers will quickly realize.

The complete drill is about the same weight, power for power, as a pneumatic drill. The only lubrication required is an occasional drop of oil on the rotation motor and on the screw-feed. The drill delivers about 2,400 blows per minute. Other types of Dorman rock-drills are worked in a similar manner.

Rivetting hammers are operated by a percussion motor in just the same way as the hammers of rock-drills. In the typical portable rivetting machine we have an example of wave power generated in close proximity to the wave motor without intervening piping. In this instance oil is used instead of water. In the top of the framing is a small dome-shaped chamber into which oil is pumped and maintained at a constant pressure. This chamber communicates through a pressure-difference valve with the generator "capacity" below it, in which the generator plunger or ram impinges on the oil. When the pressure in the "capacity" falls below the normal minimum pressure, the valve automatically opens, and by admitting more oil increases the pressure again, and when the normal pressure is restored the valve closes. The "capacity" communicates with the rivetting hammer beneath it through a hand-operated valve. The hammer is operated in exactly the same manner as the hammer of a rock-drill. The oil pump is located in the upper portion of the frame, which is divided off by a horizontal partition so as to constitute an oil-storage tank. The hammer delivers 2,400 blows per minute. As in all other wave-power appliances, when the rivetter is not in use no power is consumed by the wave generator beyond overcoming friction of working parts, the "capacity" serving to store and give back again all the energy imparted to it. To start the rivetter it is only necessary to pull down the valve handle and admit the wave impulses to the hammer head. The generator may be driven by electric motor, belt, or any other convenient means. The other mechanical features of the portable rivetter need no explanation, beyond mentioning that special provision is made for rapidly adjusting a toothed quadrant so that when the table is raised to the height required it will not rise higher.

EFFICIENCY.—We now come to the all-important question of efficiency. However wonderful an invention may be, its commercial value depends upon how it emerges from the searching test of efficiency which has doomed so many otherwise clever, scientific discoveries. Wave power has been through the test, and has emerged with such success that, if Messrs. W. H. Dorman's statements are even approximately correct (and they are backed by guarantees), the manufacturers of compressed-air plant must be living in anxious times. Probably no one deplores the shortcomings of pneumatic plant and appliances more than the makers themselves. Against a system entailing such wastage, Messrs. Dorman offer wave-power transmission plant with a guaranteed minimum efficiency of 50%, increasing to as much as 85% in many cases.

Messrs. Dorman & Company give practical demonstrations of working plant at their Stafford works, where those interested receive every attention and courtesy. Engineers are recommended to pay a visit to these works to make investigations for themselves.

"FLATS" AND "SOPS" IN FURNESS

By J. D. KENDALL.

The Author discusses the Hematite Deposits known as "Flats" or Bed-like Deposits, and "Sops" or "Pots," with Special Reference to those of Furness.

"FLATS."

In the Memoir of the Geological Survey, Vol. viii., Iron Ores: Hematites of West Cumberland, Lancashire, and the Lake District, we find, in the last paragraph on page 25, the following statement: "A noticeable absence of flats in the limestone of Furness may be due to the superabundance of fissures that lay ready for alteration." Again, on page 41, "In Furness, where flats are usually absent, vertical bores have less chance of success, &c." As there is not a "flat" referred to in that part of the Memoir devoted to Furness—except at Stank, and that reference is from information gleaned from another work—it may, I think, be reasonably inferred that the writer of the Memoir did not know of any. Yet many such deposits have been worked there.

Ore-bodies of this form are usually found as contact-deposits in limestone, on or under beds of sandstone or shale. For example, the flats in the top or first limestone of the Whitehaven district occur either immediately under the Millstone Grit formation, or on the sandstone underlying that limestone. In the first case they have a regular roof of sandstone or shale and an irregular floor of limestone, except where the deposit has the full thickness of the first limestone. There the sole or floor is sandstone. If the ore occurs mainly along the floor of the limestone, the sole will be sandstone and regular, the roof limestone, sometimes very irregular, the ore extending, at places, in "guts" up to the sandstone roof.

When the ore occurs as a flat in the seventh or bottom limestone of the Whitehaven district, it generally has a fairly regular floor of shale and an uneven roof of limestone, but in some places there is a layer of limestone between the ore and the underlying shale, as for example at Ullcoats, Fig. 1, which is wrongly referred to in the Memoir (p. 10) as a fair example of an *irregular* ore-body. On the contrary, it is entirely a flat, notwithstanding the thickening of the ore adjoining the fault. The irregular ore-bodies mainly occurred in the fourth limestone and were quite different in character from the Ullcoats deposit.

The most important flats have been found in one or other of the aforesaid positions, but they occur in all the limestones of the Whitehaven field, and in every case they have either a sandstone or shale roof, or a sandstone or shale floor, the sole or roof in the respective cases being limestone, unless, as was the case at No. 5 pit, Eskett Park, the ore had replaced the full thickness of the limestone and both roof and sole were shale.

The Carboniferous Limestone series of the Whitehaven district being split up into seven distinct beds of limestone, separated by beds of shale or sandstone, there are many horizons on which flats may occur.

The Carboniferous Limestone series in Furness is developed differently from that of the Whitehaven district. In Furness the limestone occurs in practically one solid mass, except near the top, where it is split up by comparatively thin layers of black shale leading up to the base of the Yoredales. It rests on the lower limestone shales, which are underlain by the Basement Conglomerate. It is clear therefore we can expect to find flats only at or near the top or bottom of the limestone, and then only in connection with faults. The most faulted part of the district and the part too that has been by far the most explored, is a belt of the Carboniferous Limestone, less than half-a-mile wide, bordering on the Silurians. I will therefore confine my remaining observations mainly to that area, or rather to part of it, where most work has been done. The limestone there, resting on the Lower Limestone shale, is within easy reach of the surface and numerous flats have been found and worked on the same geological horizon as the flats in the neighbourhood of Egremont and Woodend in the Whitehaven field.

The section in Fig. 2 intersects ten of these flats in the neighbourhood of Lindal Moor, and they are not all by many; but I do not propose to deal with all the flats in the district, merely to give some ground for my complaint as to the conspicuous incompleteness of the Memoir on a matter well known to mining men who have had a general experience of the district. It will be noticed that the flats are all on the downside of the faults, which is very remarkable if the hematite-producing solution came from above. Much the same thing is seen in the flats near Egremont in Cumberland.

None of the faults in the above section is

shown on the map prepared by the Geological Survey, notwithstanding their importance to the explorer. The fact of deposits having been exhausted along certain parts of those faults does not diminish their importance, nor the need for their appearing on a map that is to be of any use to the explorer.

I had occasion some time back, in a review of the Memoir, to point out some of its numerous inaccuracies, but I was reluctant to encroach upon the valuable space of THE MINING MAGAZINE or I could have gone much farther. There is, however, one serious error relating to some of the rocks of Furness, herein referred to, which I ask permission to rectify now. On p. 21 of the Memoir the thickness of the shales and limestones (the Lower Limestone shales), bored through between Dunnerholm and Ireleth, is given as 1,136 ft. The authority for the statement is said to be on pp. 64–67 of the Iron Ores of Great Britain and Ireland. But the thickness there given is 714 ft. 10 in., not 1,136 ft.

"Sops" or "Pots."

On p. 31 of the Memoir we read: "The Furness swallow-holes, after removal of the ore, show a smoothing of the walls that is characteristic of water, and presumably was effected in pre-Triassic times. When a hole ceased to serve as an open conduit, falling material filled the bottom with breccia, including masses of limestone-shales. Disintegrated shale and mud, washed in, formed a rough lining to the whole mass, and in some cases formed a plug at the bottom. Subsequently Triassic sands and clays filled the top of the swallows and covered the limestone-plateau. The mineralizing solution, entering from above, attacked this breccia, which was in a particularly vulnerable condition. As the alteration progressed the new ore packed together and led to the collapse of the roof and the overlying sands in jumbled masses."

Had the Memoir been produced 40 years ago, as it ought to have been, when the writer would have been able to see the deposits before mining operations had obscured their original features, I do not think the above passages would have been written, nor others depending on them. They are very far from explaining the facts to be seen at the time referred to. But if we look at the Park deposit, as represented by Fig. 23 on p. 137 of the Memoir, and reproduced here, in part, by Fig. 3, there is no appearance of the jumble referred to in the Memoir. There are a number of masses of sand and clay, of various sizes, distributed in, and adjoining, the ore-body, but they all occur in positions which could not possibly have been occupied if the supposed overlying sands and clays had collapsed and fallen on to the ore in the manner suggested by the Memoir. Fig. 23 of the Memoir does not show clearly the clay which occurred between the sand and the ore, and between the ore and the surrounding limestone. I therefore give, in Fig. 4, a plan of the Park deposit, at the 50 fathom level, which does show them, as proved by the mining operations prior to 1882.

It is necessary to say here that there was not any material mixing of the different minerals in and adjoining the ore-body. The ore, whether rich or poor, was always ore. There was clay, in places, in the interstices of the fragmentary hematite constituting the mass, which had evidently been washed down from the overlying glacial deposits. There was a large quantity of broken kidney-ore in the deposit and a few small loughs. The sand also was without admixture. So, practically, was the clay, although it had, in places, a few pieces of ore and stone in it. The limestone adjoining the clay was decomposed for about an inch in depth, its hardness decreasing from the unaltered stone toward the clay, against which it was quite friable. The junction of the clay and ore, in every case, was well defined; there was no mixing of the two. Equally distinct was the junction of the clay and sand and that of the sand and ore. At the 60 fathom level the sand was mainly white, but some of it was red. That immediately adjoining the red was mottled. Both red and white were in places quite hard and bedded; the red then looked exactly like St. Bees sandstone. It seemed as if the binding material was being decomposed through exposure. Blocks that were quite hard in the centre became softer outwards and ultimately quite incoherent. Another feature of the deposit which is irreconcilable with the collapses suggested by the Memoir is that many of the blocks of sand and clay are either nearly plumb, or their sides, adjoining the ore, are in parts more or less vertical, as in Fig. 3. If we suppose that the several spaces occupied by sand were originally occupied by limestone which had not been replaced by ore, that subsequently the limestone was dissolved and carried away, leaving cavernous spaces in the ore, into which the red and white sand was afterward deposited, we have a complete explanation of the existence of these sandy masses.

I have seen one or two deposits in another part of the district which consisted of a conglomeration of heterogeneous, non-ferrous, ma-

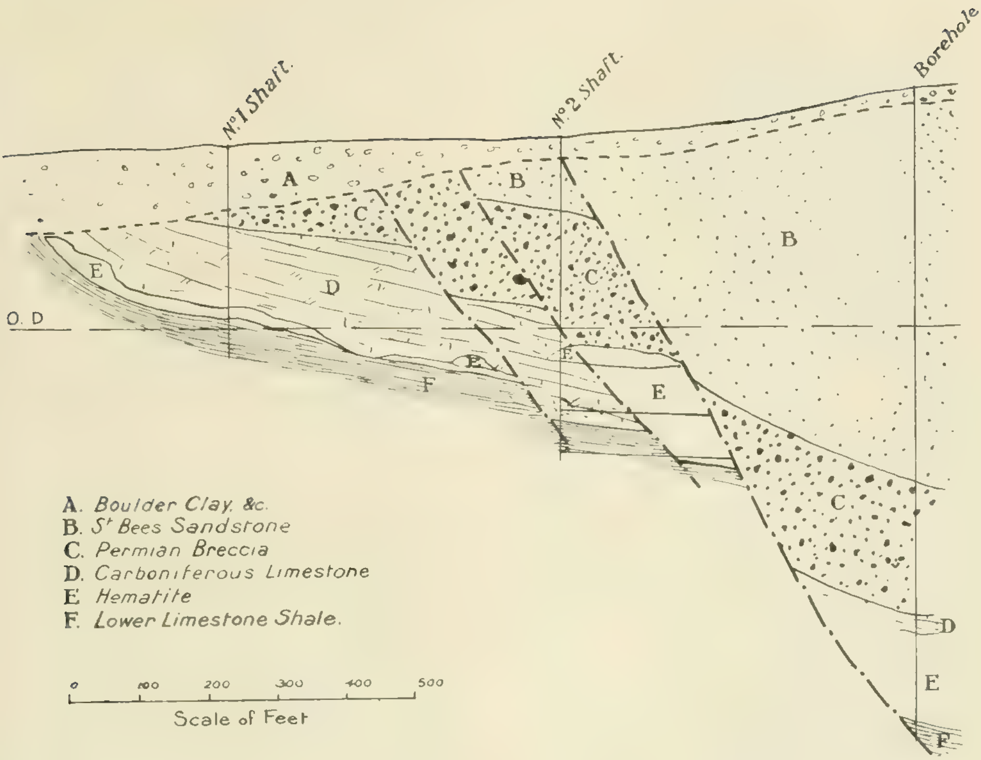


FIG. 1.

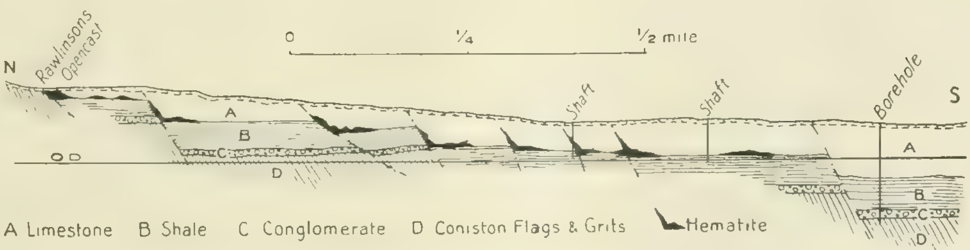


FIG. 2

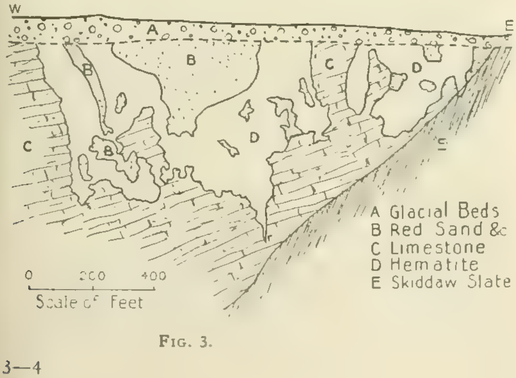


FIG. 3.

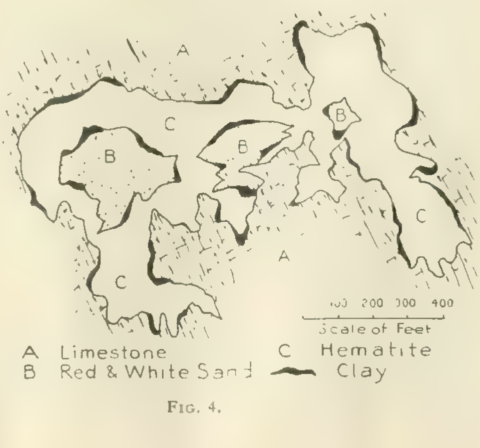


FIG. 4.

terials, through which a considerable quantity of ore was scattered, but they scarcely deserved to be called ore deposits. Yet even they could not be explained in the way suggested by the Memoir. Here is a description of the materials seen in one of them, taken from one of my 1879 notebooks: "The deposit consists mainly of brown and yellow clay, black muck, and angular bunches of what at a distance looks like white sand, but is really partly decomposed limestone. The clay is, in places, laminated, and occurs in layers of different colours, but these are not parallel to any particular plane, dipping and twisting in all directions. Ore—mostly hard pieces—is scattered sparsely through the clay generally, but, in places, it is packed in it in bunches 12 to 14 inches in diameter, the interstices of the pieces, in the bunches, being filled with soft, greasy-looking red ore. The black muck occurs, in patches too, in the brown and yellow clay, and in it there are small pieces of hard, bluish, fibrous ore, 1½ in. diameter, and less. The white sandy-looking material gives to the mass the appearance of a breccia. Each patch of that material is distinctly defined at the edges and they are mostly angular in form" (as in Fig. 5).

In the same notebook there is a description of the ore of a deposit having the ordinary "sop" character. It is as follows: "This deposit consists of closely packed angular fragments of blue ore, up to 3 or 4 inches diameter, and broken laminæ of kidney-ore. In the interstices there is a soft, greasy-looking red ore. In several parts of the deposit I found small loughs—up to 6 inches across—lined with quartz spar. Bunches of clay, 6 to 12 in. across, are met with occasionally in the ore. More rarely, large masses, 10 to 12 yards through them, are come across, which contain small fragments of ore. Clay also occurs interruptedly on the outside of the ore-body, between the ore and the limestone. In places it is only a few inches thick, in others several feet. These clayey masses occur much oftener and more abundantly between the ore and the enclosing limestone—that is, on the outside of the ore—than within it. For a foot or two from the top the ore is much mixed with 'pinnel,' that is, boulder clay by which the deposit was overlain, glaciated stones, in places, lying completely buried in the ore 12 in. or more below the top of it, and numerous pieces of ore occur in and near the base of the pinnel."

There were not any masses of red sand in either of these deposits—which were at Crossgates—as there were at Park and Ronhead. These masses are confined to deposits on the western side of the fault extending southward from Greenscaw. The reason for this will appear later.

All the sops are overlain by boulder clay which, in some cases, is much mixed with the ore, as shown in Fig. 6, a section of Rawlinson's open-cut, near Martin, as I saw it in 1874.

In explanation of the distribution of "sops" the following passage occurs on page 24 of the Memoir: "It may be assumed that in the pre-New Red times the main limestones formed a plateau, extending from the Duddon estuary north of Sandscale to near Lindal (plate III.) and dominated on the south by an escarpment of Yoredale beds. On such plateau swallow-holes and caverns abound, and to this origin the sops of ore which are found from Ronhead to Lindal, and possibly those at Kirksanton, and Water Blean, near Millom, may be ascribed. In New Red times both plateau and escarpment were overspread by New Red deposits, relics of which still survive in several places (pp. 24, 137, 142). In post-Triassic times an uplift ensued, as a result of which the Sandscale-Aldingham fault came into existence. Near Sandscale it coincided with the foot of the Yoredale escarpment, but south of Dalton it broke across it. In Newton and Yarlside mine, farther south, the fault escarpment has the irregular outline of a present-day limestone cliff. The New Red Sandstone is banked up against it."

In the first place let me say that the assumed cliff from Dalton to Lindal does not mark the limit of the sop area. To mention one instance only, as showing the inaccuracy of the assumed line, there was a sop on the boundary of the Highfield House property and that worked by the Dalton Mining Co. which was 1,200 ft. east of the assumed Yoredale cliff.

I cannot find any evidence of this supposed Yoredale escarpment at any of the three points mentioned. Nor can I find any evidence of a fault having the direction of that marked on the map (plate III. of the Memoir) between Sandscale and the railway from Dalton to Furness Abbey. The New Red Sandstone at Yarlside was not banked up against the Yoredales. The two formations were placed side by side by a fault, as shown in Fig. 7. Further, I am satisfied, if such an escarpment, as is assumed by the Memoir, ever existed, it could not have influenced the distribution of any known sops of ore. Fig. 8 is a sketch section of the geological conditions pictured by the above excerpt from the Memoir on a line between Bolton Heads and Park mines, showing a few

FIG. 5.

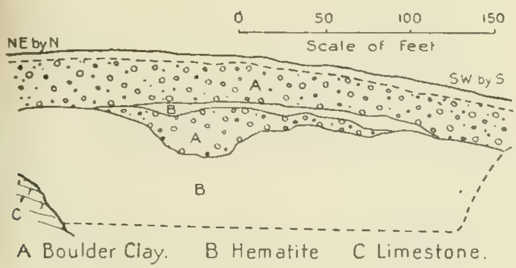


FIG. 6.

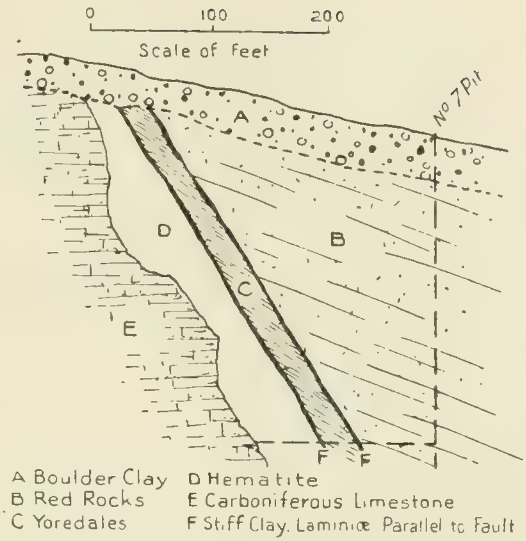


FIG. 7.

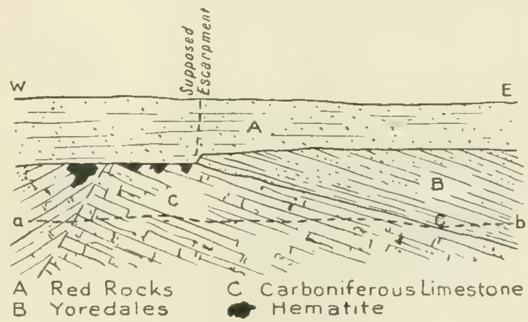


FIG. 8.

sops under the Triassic sandstone. Since the days when those conditions existed, the rocks have been so denuded that the rise edge of the Yoredales is now about a mile and a half east of the supposed escarpment (*c*, Fig. 8) and the surface of the ground is at the level represented by the dotted line *a b*, so that the sops, which were supposed by the Memoir to have been formed immediately below the Red Rocks, were destroyed ages ago, and the postulated escarpment as well.

Let us now see if there is not a simple explanation of the occurrence of the masses of sand and clay associated with the sops that does not require any collapsing caverns, nor the assumption that the ore in the sops was formed otherwise than by the replacement of solid limestone like that in all the other deposits.

In mining the sops, it was not an uncommon thing to break into a cavernous space between the clay or black muck and the limestone. These caverns were sometimes several feet wide and extended up to the boulder clay, as well as horizontally along the deposit. In wet weather great quantities of water came down them into the mine, which were costly and troublesome to deal with. So long as there was a through passage for free circulation there would not be any deposit in such caverns, but if the circulation were impeded there would be a deposit and the cavern would eventually be filled with clay, or clay and black muck, perhaps including a few pieces of ore or stone.

The initiation of these caverns and of all those now filled with clay between the ore and the limestone, or between the ore and sand—whether on the outside of an ore-body or within it—most probably arose as follows: The ore, consisting chiefly of packed fragments, would allow water to circulate through it, and as the outlets would be less than the inlets, the sops would soon be saturated with water, which would extend to the walls in all directions. If that water was acidulated—as it almost certainly would be, being rain water which had passed over decaying vegetable matter—it would attack the limestone walls wherever it reached them, unless they were too silicious, and produce a number of caverns along the outside of the deposits, and, in a similar way, round about the pieces of limestone included in the ore-body. These would afterwards be filled with clay and black muck, the junctions of which with the ore would be quite distinct, as we actually find them.

The clay existing between the ore and the sand must have been deposited before the sand. The limestone which preceded the sand must, therefore, have been removed by dissolution after the clay, adjoining the ore, had been filled into the first-formed caverns, in the same way as the limestone was dissolved out of where the two clay loughs now are in Fig. 1 of "The Distribution of Ore in Depth" (see THE MINING MAGAZINE, May, 1920). It is not necessary that the caverns into which either the clay or sand was deposited should have been of the final size of the clay or sand masses before being filled, as dissolution and formation might be going on at the same time.

I am satisfied the source of the clay was the boulder clay overlying the deposits and the sand came from the large area of Red Sandstone, about half a mile south of the sops, where disintegrated rock occurs abundantly. The top of any of these sops is not more than about 25 ft. above sea level. But the Red Sandstone area to the south of them, from Thwaite Flat to Sinkfall, is from 125 to 225 ft. above that level. To anyone familiar with the swallow-holes of Furness—and the distances to which the water is carried underground by them—the deposition of sand from this source in the sops of Ronhead and Park will appear a very simple process, and one in strict conformity with what we know is going on in the district to-day. There would be an average hydraulic gradient of at least 1 in 30, which is more than sufficient for the purpose, and would allow a good deal of current retardation.

There are not any sand masses in or on the sops occurring in the eastern part of the district, as there ought to have been if the Red Sandstone had been deposited on all the sops alike, as the Memoir supposes. Why is this? The answer is that the ground in the eastern part of the district, where the sops occur, is higher than that in either of the Red Sandstone areas, being from 250 to 375 ft. above sea level, whereas the highest Red Sandstone does not exceed about 225 ft.

Let us now devote a little further consideration to the ore. It is not necessary to look long at any of these sops to be convinced that the ore in them has been subjected to some severe internal strain by which the fragmentary condition now existing was brought about. Incontrovertible evidence of this is furnished by the broken "shells" (concretionary layers) of kidney-ore which form so large a part of most of, if not all, these deposits. In some deposits half of the ore seems to be broken kidney. This form of hematite, as is well known, was formed on the walls of loughs, but there are very few loughs now in the sops, and the broken concretionary layers of the kidney-ore are buried indiscriminately in the fragmentary mass. Another thing to be borne in mind is that the kidney-ore is in places very soft and easily broken or crushed into powder. Here is a note made on the Parkside Co.'s Pennington mine in 1877: "Much of the kidney-ore near the hanging wall is as soft as clay, but has the true kidney structure."

We may now conveniently direct our minds back to the dawn of the Glacial period, when, by the ordinary forces of denudation the upper part of the ore deposits, as originally formed, had been removed, the lower part, or sops, only remaining. The ore in them was then doubtless in the loughy condition of its formation, and the loughs would as certainly be full of water. Soon the intense cold of that period would freeze the water and exert such an irresistible strain on the ore in all directions and from so many centres in each deposit that the ore would be ruptured throughout and the fragmentary condition produced that is so characteristic of the sop-ore to-day.

When the glaciers receded, and acidulated waters began to circulate through the broken ore, the limestone would be attacked and cavities produced in which clay first and afterward sand accumulated. It ignores the work done by the forces of denudation to assume, as the Memoir does, that the red sand was deposited in Triassic times. As shown in Fig. 8, the limestone on which the Red Rocks were laid was hundreds of feet above the Park and Ronhead deposits and disappeared in days that are now far distant even in a geological sense.

The above explanations regarding the sand, clay, and ruptured ore were first put forward in "The Hematite Deposits of Furness" (see Transaction, North of England Institute of Mining and Mechanical Engineers, Vol. xxxi., 1882), but with much less detail than I have thought it necessary to introduce here.

The Ceramic Society, of Stoke-on-Trent, will hold a joint meeting with the French Ceramic Society in May. After the sessions in Paris, there will be excursions to pottery districts in Alsace and Lorraine. Train will be taken to Metz, and afterward Merzig, Mettlach, Sarreguemines, Strasbourg, Soultz-sous-Foret, and Oberbetschdorf will be visited. On the return to Paris a visit to the Sevres porcelain works will probably be arranged.

ON THE ESTIMATION OF PHOSPHORIC ACID BY THE MOLYBDATE METHOD.

By J. E. CLENNELL, B.Sc., Assoc.Inst.M.M.

Difficulties of the Molybdate Method.

The fact that this method has already been the subject of a large amount of experiment is evidence that its execution, as generally carried out, presents considerable difficulties. These difficulties arise from the following causes: (1) the variable composition of the precipitate according to the conditions of precipitation; (2) the solubility of the precipitate in water or in the liquids from which it is deposited; (3) its liability to decomposition on heating; and (4) its hygroscopic nature.

The errors due to these causes may be avoided, or at least minimized, by working under strictly defined conditions, and the writer has recently carried out a number of experiments to determine the correct conditions in the case of such substances as the soluble phosphates of the alkalis and ammonium, and of phosphates like that of aluminium which are insoluble in water, but soluble in dilute acids.

Literature of the Subject.

The chief causes which affect the composition and physical condition of the precipitate are temperature, dilution, acidity, the presence of certain salts such as those of ammonium, and the addition of a larger or smaller excess of the precipitant. Some of these conditions have been fully investigated by other workers, and the following references may be consulted:

Hundeshagen, *Zeit. Anal. Chem.*, 28, 141 (1889).

J. C. Olsen, "Text-book of Quantitative Chemical Analysis" (1904), p. 113.

A. Blair, "Chemical Analysis of Iron," 3rd ed.

A. H. Low, "Technical Methods of Ore Analysis," 5th ed. (1911), p. 209.

J. W. Mellor, "Quantitative Analysis (Ceramic Industries)," 1913, p. 590.

O. Bauer and E. Deiss, "Sampling and Chemical Analysis of Iron and Steel" (1915), p. 223.

Lord and Demorest, "Metallurgical Analysis," 4th ed. (1916), p. 49.

Conditions of Precipitation.

From these writers it may be gathered that the precipitation of phosphoric acid by molybdate solutions proceeds best at a temperature of about 45° C. In cold solutions, the precipitate settles slowly and is difficult to filter, and at a temperature above 60° C. white needles of ammonium tetra-molybdate may be produced. Free HCl or H_2SO_4 must be absent, but a small amount of free HNO_3 is necessary. A large excess of any of these acids causes incomplete precipitation. Ammonium nitrate hastens precipitation, but ammonium chloride and ammonium sulphate retard it. With regard to dilution, Olsen (loc. cit.) states that the phosphate solution should have 100 mgr. P_2O_5 in every 25 cc. Free HNO_3 should be present to the extent of 26 molecules to 1 molecule of P_2O_5. 80 cc. of the standard molybdate (which represents 6 grm. of ammonium molybdate) should be present for every 100 mgr. P_2O_5; this standard solution contains 75 grm. ammonium molybdate and 250 cc. concentrated HNO_3 per litre. Enough ammonium nitrate, 750 grm. per litre, should be added to constitute 15% of the total volume.

Conditions of Settlement and Filtration.

After precipitation, the mixture should be stirred vigorously, say for 5 minutes, and allowed to settle. The time and temperature of settlement are variously given by different writers, but in general not less than one hour is required, and the mixture should be allowed to stand in a warm, but not too hot place, until the supernatant liquid is perfectly clear. It is then filtered. Owing to the solubility of the precipitate in pure water, it must be washed with a liquor containing free HNO_3 and NH_4NO_3. When the volumetric determination by alkali is to be used, a final wash of potassium nitrate is given, to remove all free HNO_3 and ammonium salts.

Final Treatment of the Precipitate.

The final treatment of the precipitate may be varied in many ways, thus:

(1) It may be collected on a weighed filter, washed as directed above, dried, and weighed direct as ammonium phospho-molybdate. This involves all the difficulties due to the solubility, variable composition, instability, and hygroscopic nature of the precipitate.

(2) It may be filtered off, redissolved (say) in ammonia and re-precipitated as magnesium ammonium phosphate, and finally ignited and weighed as magnesium pyro-phosphate. This method avoids the difficulties involved in preparing ammonium phospho-molybdate of constant composition, and the necessity for a weighed filter, but still involves the filtration of the phospho-molybdate and errors due to the solubility of this compound, together with the additional errors involved in the manipulation

of the magnesium compound (solubility of the latter in the mother liquor and impurities retained after ignition to magnesium pyrophosphate).

(3) The ammonium phospho-molybdate precipitate, after filtering and washing, is dissolved in any suitable way and converted into lead molybdate, which is filtered off, ignited, and weighed. This is an indirect gravimetric method in which the amount of P_2O_5 is deduced from the amount of molybdenum used to precipitate it, and involves any error due to variable composition of the original phospho-molybdate precipitate.

(4) Various volumetric methods are in use, in which the P_2O_5 is indirectly determined, either by estimating the amount of alkali which the compound is capable of neutralizing, after it has been washed to remove all free acid, or by estimating the molybdenum content, for example, by permanganate after reduction with zinc and sulphuric acid.

Author's Modification.

I will now give an account of my own experiments. These experiments were made chiefly on methods involving (1) the direct weighing of ammonium phospho-molybdate; (2) the volumetric estimation by consumption of alkali. The preliminary operations are the same in both cases, and the method finally adopted was as follows: A weighed quantity of the salt or a measured quantity of solution is taken, containing about 50 to 75 mgr. of P_2O_5 (the amount should be approximately known by a preliminary test). This is dissolved in water if necessary; if insoluble in water, it may be dissolved in 25 or 50% HNO_3, warming till solution is complete.

Precipitation of Soluble Phosphates.

In the case of a neutral (aqueous) solution, this is then mixed with 60% of its volume of acid ammonium nitrate (3 volumes conc. HNO_3, 2 volumes conc. ammonia, and 7 volumes water). The mixture is heated to 45° C. and mixed with a small excess of 8% ammonium molybdate, previously heated to the same temperature. It is important to avoid a large excess of molybdate. About 33 parts by weight of ammonium molybdate was found to be sufficient for complete precipitation of 1 part of P_2O_5 under the conditions of the test. Olsen's figures imply 60 parts ammonium molybdate for 1 part of P_2O_5, but the present writer finds that any considerable excess beyond that indicated above results in the formation during settlement of a white crystalline deposit containing molybdenum and ammonium, presumably the ammonium tetra-molybdate referred to by Mellor (loc. cit.), even when the temperature is kept strictly within the limits recommended during precipitation and settlement. The mixture is then agitated briskly for 5 minutes and set aside to settle in a moderately warm place for at least 2 hours. It is not desirable to let it stand too long, as in some cases the white deposit referred to gradually forms.

Treatment of Aluminium Phosphate.

In testing aluminium phosphate, 100 mgr. of the finely ground substance, after recent ignition and cooling in a desiccator, is weighed out and warmed with 30 cc. of 50% HNO_3. This generally dissolves it completely in a few minutes. Ammonia, 50% strength, is then added till the mixture is just alkaline, then 30 cc. of the acid ammonium nitrate referred to above, and the mixture boiled. Occasionally a minute residue remains. This is filtered off, dried, ignited, fused with sodium peroxide, extracted with water, and the extract added to the main solution. Experiment showed that this insoluble matter does not, as at first supposed, consist of silica, but is only a part of the aluminium phosphate which, for some cause not ascertained, shows great resistance to the action of the HNO_3. This refractory material usually occurs in acid phosphates, formed by precipitation of aluminium with a large excess of soluble phosphate. When a perfectly clear solution has been obtained, this is heated to 45° C. and mixed with ammonium molybdate at the same temperature. Usually 25 cc. of an 8% solution of ammonium molybdate is a suitable amount, but this must be regulated by the approximately known P_2O_5 content of the substance to be analysed. From this point the procedure is exactly the same as with soluble phosphates.

Gravimetric Determination as Phospho-Molybdate.

For the direct determination as ammonium phospho-molybdate, the clear liquid is decanted through an alundum crucible which has been previously ignited and weighed. Portions of the filtrate are used for transferring the whole of the precipitate to the crucible. The filtration generally proceeds rapidly under slight vacuum, yielding a perfectly clear filtrate, which should not give any further deposit on adding a small quantity of nitric acid or of ammonia, when warmed to 45° C. and allowed to stand. It should also give no yellow precipitate with further addition of ammonium molybdate, but if much of the latter be added, a white precipitate, as stated above, will eventually appear. Three or four washes are now given with dilute acid

ammonium nitrate (5% NH_4NO_3 + 2% HNO_3), filling the crucible up each time and allowing to drain completely before giving the next wash, then 2 or 3 washes of 2% HNO_3 applied in the same way. This is apparently sufficient to extract all soluble impurities and the excess of ammonium salts without redissolving any appreciable amount of the ammonium phosphomolybdate. The crucible is now placed in a drying oven at 110° C. and weighed at intervals till constant weight is obtained. This is the most unsatisfactory part of the whole operation, as prolonged drying is required to eliminate every trace of moisture, and at some point not determined the precipitate begins gradually to decompose at a temperature not exceeding 120°C. The difficulties due to the hygroscopic nature of the precipitate were overcome by weighing the alundum crucible and contents inside a larger vessel with a fairly close-fitting cover (for example, a nickel crucible with lid) to which it is quickly transferred from the desiccator previous to weighing. The weight of precipitate is found by deducting the combined weights of the empty alundum crucible and containing vessel. While accurate results were sometimes obtained by this method, the uncertainty as to the true final weight made the procedure very troublesome. Further tests would be necessary to determine the best conditions for drying the precipitate to constant weight.

Volumetric Method.

After precipitating and settling as above, the clear liquid is decanted through a 9 c.m. paper filter, leaving the precipitate as much as possible in the vessel in which settlement took place. The precipitate is then washed by decantation 5 times with dilute acid ammonium nitrate (5% NH_4NO_3 + 2% HNO_3), then with a 3% potassium nitrate solution, until the washings no longer react with litmus (this requires 5 or 6 washes). All decanted liquor is passed through the filter. The material on the paper is then washed back as far as possible into the vessel containing the bulk of the precipitate by means of a jet of hot water from a wash bottle. N/10 caustic soda is then run slowly from a burette through the paper until every trace of yellow precipitate has dissolved from the latter, collecting in the vessel containing the precipitate. Enough NaOH is added from the burette to dissolve all the precipitate and give a clear solution, distinctly alkaline to phenol-phthalein. The paper in the funnel is then washed 4 or 5 times with small quantities of hot water, which also runs into the containing vessel. The completeness of the washing may be tested by adding a drop of phenol-phthalein to the paper. The mixture is allowed to stand a few minutes, and the excess of alkali is then titrated with N/10 sulphuric acid. The end-point of the titration is not absolutely sharp, perhaps owing to the unavoidable presence of ammonia in the final liquor, but as 1 cc. N/10 alkali represents only 0·307 mgr. P_2O_5, the error from this source is negligible.

Illustrations of above Methods.

(1) By the gravimetric method:

Sodium Phosphate.—A solution was prepared containing 0·5% of the salt, supposed to be $Na_2HPO_4,12H_2O$. Duplicate tests were made on portions of 50 cc. = 250 mgr. of the salt.

	No. 1 Grm.	No. 2 Grm.
Combined weight of nickel and alundum crucibles	61·846	62·936
Successive weights of crucibles and precipitate, weighed at intervals	63·145	64·302
	63·138	64·293
	63·145	64·297
Accepted weight of dry precipitate	1·292	1·297
P_2O_5 mgr. on 50 cc.	48·84	49·03
P_2O_5 per cent in the dry salt	1[illegible]·54	19·61
(theoretical)	19·[illegible]0	

Factor assumed. Precipitate × 0·0378 = P_2O_5

Ammonium Phosphate.—A solution was prepared containing 0·25% of the salt, supposed to be $(NH_4)_2HPO_4$. Tests on 50 cc. = 125 mgr. of the salt.

	No. 1	No. 2
Combined weights, nickel and alundum crucibles	61·836	62·987
Successive weights of crucibles and precipitate, weighed at intervals	63·690	64·833
	63·679	64·823
	63·664	64·813
Accepted weight of precipitate	1·828	1·826
P_2O_5 mgr. on 50 cc.	69·10	69·02
P_2O_5 per cent in the dry salt	55·28	55·21
(theoretical)	53·8	

Aluminium Phosphate.—100 mgr. of two different samples treated as described above.

	No. 1	No. 2
Combined weights of empty crucibles	61·843	58·103
Successive weights of crucibles and precipitate weighed at intervals	63·396	59·778
	63·376	59·771
	63·377	59·771
Final weight of precipitate	1·534	1·668
P_2O_5 mgr. and per cent	57·99	63·05

Theoretical for $AlPO_4$ = 58·15.

(2) By the volumetric method:

Ammonium Phosphate, 0·25%.

Test No.	Vol. taken	Acid Ammon. Nitrate*	8% Ammon. Molybdate	N/10 Alkali added	N/10 Acid required	N/10 Alkali consumed	P_2O_5 mgr in vol. taken	P_2O_5 per cent in salt
	cc.	cc.	cc.	cc.	cc.	cc.		
1	25	15	15	123·4	11	112·4	34·51	55·2
2	25	15	15	123·4	10·5	112·9	34·66	55·5
3	50	30	30	227·8	1·8	226·0	69·38	55·5
4	50	30	30	2[illegible]7·3	9·7	227·6	6[illegible]·87	55·9

Factor: 1 cc. N/10 alkali = 0·307 mgr. P_2O_5

Aluminium Phosphate, 100 mgr., 3 different samples.

No.	N/10 Alkali taken	N/10 H_2SO_4 added	N/10 Alkali consumed	P_2O_5 mgr. or per cent
	cc.	cc.	cc.	
1	198·9	9·2	189·7	58·25
2	198·9	6·[illegible]	192·[illegible]	5[illegible]·04
3	198·9	6·7	192·2	59·01
		Theoretical for $AlPO_4$		58·15

BOOK REVIEWS

Geology of Petroleum. By W. H. EMMONS. Cloth, octavo, 625 pages, illustrated. Price 36s. New York and London: McGraw-Hill Book Company.

With the very rapid advancement of oilfield geology, and in view of the enormous amount of geological data accumulated during the course of exploration for petroleum in all parts of the world within the last twenty years, it seems almost incredible that the much-needed textbook on the subject should have been delayed until the present time, more especially when we consider the magnitude of the literature dealing with most of the other important economic aspects of natural science. We do not for one moment suggest that the various technical publications on oil that have appeared in the past have been deficient in quality or wanting in scope, but they have comprised essentially specialized, general, or popular treatises on the subject, and have had their obvious limitations in each case.

To students of petroleum technology, and more particularly to those training as oil geologists, a knowledge of the geologic conditions obtaining in the principal oilfields of the world must be a *sine quâ non* to their technical education; such knowledge in the past must of necessity have been derived from lectures at a training college or from laborious research into the official memoirs of geological survey for oil issued by the several countries concerned, and only those who have applied themselves to such intensive study can appreciate the difficulties and enormous range of the task.

It is not so much a question of the fundamental principles of oil technology, or of the technique of oil and gas production; these branches of the subject are treated exhaustively in many well known publications. But when it becomes a matter of the stratigraphy, structure, mode of occurrence, and economics of a particular oilfield, where is the textbook to which we can refer to save recourse to the more detailed official volumes? The answer to that question is to be found in the publication of the present book, since Dr. Emmons has fortunately decided to deliver his course of Geology of Petroleum lectures (customarily given at the University of Minnesota) to a larger audience, and in offering these lectures in their present form he has filled a gap which both teacher and student will gratefully acknowledge.

The book contains two distinct sections; the first, occupying about one-third of the volume, deals with the first principles of the subject by way of introduction to a broader and more detailed consideration of the world's oilfields, which composes the larger section. On first taking up the volume, we were inclined to glance somewhat cursorily at these first fourteen chapters of introductory matter, because we instinctively expected a repetition of the orthodox story of oil with its origin, causes of migration, accumulation, etc., but certain headings attracted attention, particularly those defining chapters 2, 10, 12, and 14, dealing with surface indications, structural features of oil and gas reservoirs, metamorphism of petroleum by dynamic agencies, and petroliferous provinces respectively. A careful perusal of these led to a closer study of the associated chapters, and any preconceived ideas were soon dispelled by the fresh, convincing manner with which the author handles this introductory subject matter. There is no "laying down the law" in this section, and the elasticity of argument which the author has allowed himself not only gives the reader food for thought, but stimulates interest in the more purely philosophical criteria engendered. In this connection his passing reference to petrographic methods of determination of the composition of reservoir rocks (p. 58) will doubtless set many geologists thinking hard, for though by no means a new idea, such methods, with their far-reaching importance in stratigraphical correlation over small areas, have yet to be more generally applied.

Passing now to the larger division of the work, that dealing with individual oilfield geology, the plan adopted in the description of each region consists of a discussion of the general features, stratigraphy, subterranean structures, mode of occurrence, and economics of oil production, supplemented with more local details of the better known districts within the region under consideration. Maps, horizontal and vertical sections, well records, statistics of production, and explanatory diagrams are lavishly distributed throughout the book, making reference easy and text details simple to understand; in addition, the short bibliography appended to each discussion of a particular region greatly enhances the value of the volume.

It is probably only natural that by far the larger part of this section of the work is devoted to a consideration of the oilfields of the North American continent; possibly in this fact alone are we able to level a slightly adverse criticism of the book, since the proportion of a little over 300 pages to those fields and about 86 to the rest of the world seems at first somewhat incongruous. It must be realized, however, that the amount of technical literature on the North

American oilfields far outweighs that of any other country, and further, the excellence and thoroughness of that literature renders a more universal understanding of the oil conditions of that continent a matter of comparative simplicity. It is therefore not surprising that the descriptions of these fields are fuller and, on the whole, more comprehensive than those of the European, Asiatic, and other fields, a matter which will probably receive adjustment in future editions of the work.

For after all, the educational value of the book is not so much centred about the discussions of American oilfields (notwithstanding their superlative importance in regard to actual oil production) as about the broader geologic principles to be deduced from a study of fields all over the world; it is the author's grasp of this essential which completely justifies the publication of the volume and which proclaims it as unique in the literature of petroleum geology, and we hope that this wider view of the scope of the work will be even more rigidly taken in future editions than in the present case. In this way Dr. Emmons will maintain a live textbook which can never become out of date.

We venture to congratulate both author and publishers on the production of a volume which, for excellence of material and literary merit, deserves a very wide circulation.

H. B. MILNER.

Le Platine et les Gîtes Platinifères de l'Oural et du Monde. By LOUIS DUPARC and MARGUERITE N. TIKONOWITCH. Paper covers, quarto, 542 pages, illustrated, accompanied by an Atlas containing 5 Geological Maps and 8 Plans. Geneva: Société Anonyme des Editions Sonor.

Ever since 1900 Professor Duparc and his scholars have devoted considerable time, intense energy, and genial thought to the study of platinum and platiniferous deposits. The result of their study is contained in the book under review. It is divided into 17 chapters, an introduction, and a list of 123 reference books. All is so extremely thorough and interesting that we do not hesitate to mention the titles of the various chapters.

(1) The Urals from the topographical and geological aspect.

(2) Matrix of platinum, distribution, and general characteristics of the primary platiniferous centres.

(3) Petrography of the primary platiniferous centres; dunite and the peridotites.

(4) Pyroxenites and koswites.

(5) The rocks of the gabbro group.

(6) The vein rocks.

(7) Metamorphic rocks adjacent to the platiniferous eruptive zone.

(8) Distribution of the platinum in the matrix and primary platinum deposits.

(9) Analysis and chemical composition of the platinum compounds.

(10) Secondary deposits and platiniferous alluvials.

(11) Platinum extraction from alluvial deposits.

(12) Description of the dunitic centres in the Urals.

(13) Description of the pyroxenitic centres in the Urals.

(14) The world's platiniferous deposits outside those of the Urals.

(15) Metallurgy of platinum.

(16) Industrial uses of platinum.

(17) Platinum production and general statistics.

Duparc establishes most convincingly that dunite is the pre-eminent matrix of platinum, that pyroxenite may be a matrix of minor importance, and that gabbros for all practical purposes may be considered sterile. The relationship of these rocks is very closely studied, and numerous varieties of transitional character are minutely described. The transitions from one rock into another are closely gone into, and the origin of uralization is explained.

The platiniferous dunite centres, more or less of elliptic shape, are generally within a band of pyroxenite, the latter being surrounded by extensive masses of gabbro. Dunite is held to be a product of magmatic segregation from pyroxenite, the latter being similarly derived from gabbro. Dunite, which consists essentially of olivine and chromite, contains the platinum associated with the latter, but never in sufficient quantity to allow of a remunerative mining of platinum from the rock in situ.

Dunite is a deep-seated rock, and exposed only in consequence of extensive denudation. In the majority of cases, rivers which take their origin in dunite centres, or after passing through these, contain platiniferous gravels; exceptionally pyroxenite centres of definite composition have yielded platinum to river gravels originating in or passing through them. Eleven dunite centres have been located in the Urals, whereas only five pyroxenite ones are known. The crude platinum from different dunite centres is of variable composition and contains from 60·39% to 84·60% of pure Pt, while that derived from pyroxenite centres contains from 78·40% to 88·54% of pure Pt.

One cannot speak too highly of the geologi-

cal and petrographical work contained in the book, and unstinted praise is due to the thorough elaboration of a reliable chemical analysis for crude platinum.

There are also mentioned in the book practical results of applied economic geology, several platinum deposits having been located by the author and his pupils as results of geological field-work. The platiniferous deposits in other parts of the world are summarily described as results of personal inspection by the author or at the hand of trustworthy information.

The criticisms of the book chiefly apply to the purely technical part, where we find measurements given indiscriminately in metric, English, or Russian units. On page 410 the alluvial deposit of the river Bolshaia Sosnowka is given in Russian units, and overleaf (page 412), when describing the river Logwinska of the same river system, metric units are applied. It is also regrettable that platinum contents in the gravels are chiefly given in doli or zolotnik per 100 pood, which do not convey anything to the reader unacquainted with Russian units. At least a conversion table should have been provided. The same remark applies to the plans of machinery where archines, vershoks, metres, and feet are used anyhow. The frequent use of foreign words should be avoided, such as lojok, ouwal, retchniki, peski, and many more, when describing Russian platinum deposits. All such words jar, and moreover cannot be found in a French dictionary. The climax in the use of foreign words is to be found on page 475, where the author says: "The bore-holes carried out by Mr. Orueta on the alluvial deposits of the Rio Verde as well as on other *rios* of the region."

When discussing the methods which have been used for prospecting platiniferous alluvial deposits the author claims that results obtained with the Empire drill are unreliable, and that the drill is quite useless for the prospecting of such deposits. That may be so, yet he describes the drill fully and gives numerous illustrations thereof, and even calls it a diamond-drill in a photo facing page 284.

The only reference of a dry assay for platinum from its matrix is to be found on page 194, where it is mentioned that when platinum is not visible in a rock the latter may be crushed and panned appropriately, or it may be subjected to a lead fusion and the lead button cupelled. This method is, however, far from reliable, and deserves special study and elaboration. The results contained in the tabulated statement of page 195 and referring to platinum contents in dunite are therefore not convincing; further details of the methods employed by the various operators would be generally welcomed.

These criticisms are, however, trifling, and the causes leading thereto can readily be avoided in a revised edition. In all other respects the publication is and will remain a standard text-book on platinum and its deposits. All those interested in that precious metal, be it from the geological, petrographical, or chemical point of view, will welcome this publication of undoubtedly great merit. The geological maps published in connection with the book are models of accuracy and valuable guides for similar investigations. The illustrations generally are clear and good; particular interest attaches to those of famous platinum nuggets which have vanished during the Russian revolution.

A. L. SIMON.

Die Sulfid - Silikatschmelzlösungen, I: Die Sulfidschmelzen und die Sulfidsilikatschmelzen. By J. H. L. VOGT. Vidensk. Selsk. Skrifter, I Mat.-nat. Klasse, 1918, No. 1. 132 pp., with 45 text-figures. Kristiania, 1919.

Die Sulfid-Silikatschmelzlösungen. By J. H. L. VOGT. Norsk. Geol. Tidsskr., vol. iv., 97 pp., with 13 text-figures. Kristiania, 1917.

[This review appeared in the *Geological Magazine* for February, and is reproduced here by permission of the Editor.]

These two publications contain the results of researches undertaken by Professor Vogt during the last few years on the physical chemistry and mineralogy of the sulphides and their relation to silicate melts, with special reference to the slags obtained in the smelting of copper matte. The first-named and larger work forms a third part of Professor Vogt's well-known work "Die Silikatschmelzlösungen"; the second contains a summary of the results set forth in the larger volume, published at an earlier date owing to difficulties encountered on the production of the complete work under war conditions. We are also informed in a preface that another memoir is in preparation dealing specially with the nickeliferous pyrrhotite ore-bodies, which are here only referred to incidentally. The publication of this will be anticipated with much interest by all mining geologists. Professor Vogt also states that he has in hand a nearly completed work on crystallization and magmatic differentiation in the basic intrusive rocks.

The facts here set forth are of the greatest possible interest, both in their technical applications to furnace practice and in their bearing on theoretical petrology and the genesis of the sulphide ores. It is now generally accepted

that silicate melts of whatever composition are completely miscible in all proportions, but with regard to the relations between fused silicates and sulphides the conditions are quite otherwise. Silicate and sulphide melts, as well as silicates and molten metals, possess only very limited mutual solubilities, and in the fused state must form systems of two liquid phases. This proposition is, in fact, self-evident, since it forms the foundation of all smelting processes. Pig iron and slag separate in the blast-furnace, not because the molten iron is heavier than the slag, but because the two liquids are mutually insoluble at the furnace temperature, and the same applies to the separation of sulphide and slag in copper matte-smelting. In both these processes it is obviously desirable to have the cleanest possible separation of metal or sulphide and slag, and it is the investigation of the conditions most favourable to this clean separation that is the chief object of Professor Vogt's researches.

In the first place, it is evidently desirable that the slag should be as liquid as possible, partly in order that it can be drawn off easily and partly to facilitate the sinking of globules of sulphide, which might otherwise remain entangled in a viscous slag. This can be obtained partly by employment of a very high furnace temperature, which is undesirable from the point of view of fuel consumption and running costs. It is found, however, that the viscosity of the slag is very clearly a function of its chemical composition, and especially of its silica percentage. This also has a very important bearing on the solubility of sulphide in slag; this solubility varies inversely as the silica percentage, and directly as the temperature. Very basic slags at a high temperature cause the greatest losses of copper in matte-smelting, and this loss is apparently increased by the presence of much zinc. The practical problem is therefore to find the best working conditions, so that the two opposed factors may compensate each other. The loss of copper inevitable with a liquid basic slag in which the solubility is high has to be balanced against the loss of copper in a viscous acid slag with low solubility, but with a strong tendency to mechanical retention of sulphide. This is a nice example of the application of mineralogy and petrology to problems of the highest practical importance, a point of view which appears to be scarcely appreciated by British petrologists.

Rather more than half of the smaller work here reviewed is devoted to a discussion of the nickeliferous sulphide segregations and their relation to the norites. This is presumably a summary of the forthcoming larger publication before mentioned. It is shown that nickeliferous sulphides have a strong tendency to occur along with rocks rich in rhombic pyroxenes, which are mainly magnesia-iron silicates, rather than with the more calcareous diopside-rocks or normal gabbros. A few sulphide masses of this type are found along with olivine rocks, especially peridotites. The physical chemistry and equilibria of the norite magmas are discussed, and it is shown that many of them approximate closely to eutectic composition (anchi-eutectic rocks). Most of the great pyrrhotite deposits are associated with norites that contain more hypersthene than corresponds to the eutectic limit between labradorite and hypersthene; where felspar is in excess sulphide segregations are much less common. In the cases described it is quite clear that the pyrrhotite crystallized later than the pyroxenes, olivine, and felspars. Incidentally it is of interest that, however quickly cooled, sulphides are always completely crystalline; no such thing as sulphide glass is known to exist. This behaviour is in strong contrast to that of the silicates. Likewise, it appears that owing to the highly mobile nature of fused sulphides, under-cooling does not occur to any appreciable extent, but sulphides crystallize sharply close to their true freezing-point.

All the phenomena attending the occurrence and crystallization of the sulphide segregations and their consanguineous silicate rocks become easily intelligible when it is once fully realized that silicates and sulphides possess very limited mutual solubility, and at the normal temperature of intrusion must of necessity form two liquid phases; this conception greatly helps in the solution of the problem of the genesis of the great nickel deposits of Sudbury and others, a problem which has of late years led to so much discussion by many petrologists, both from its inherent interest and from its great technical importance.

R. H. Rastall.

[Other notices of new books and pamphlets will be found on page 192.]

The Australasian Association for the Advancement of Science was not able to hold its annual meeting at Hobart owing to the shipping strike, and the sittings were held in Melbourne instead. Sir Baldwin Spencer delivered the presidential address, and Sir Edgworth David gave a lecture on "The Romance of Ice." There were special discussions on "The Physical Sciences in Warfare" and "The Constitution of the Atom."

LETTERS TO THE EDITOR

The Greenside Lead Mines.

The Editor

Sir—I shall be glad if you will find space for a reply to your correspondent who contributed to the January issue an article under the heading: North of England Lead and Zinc-Mining in 1920. I think it would only be fair to say in regard to the Greenside Mines that the sole reason the present company do not propose to continue operations after a certain time is because the proposed royalties for the granting of a new lease were too high in the opinion of the directors of the company. It is early yet to say, as your correspondent puts it, that it will permanently close down. Knowing the proposition perhaps a good deal better than your writer, I may say it is not likely to cease as quickly as supposed. The mines have been in operation over a century without a stoppage of any moment, and within the last 60 years have returned to shareholders approximately £400,000, a return equal to 14% on the actual capital. It may not be out of place to say the present company offered to purchase the royalties, but as the price could not be agreed upon, it remained to try and get better terms on a royalty basis, which was not considered favourable at the time. The property is a low-grade proposition, but under a favourable royalty it could carry on even with lead at its present price, and there would be no need to close, as in the case of most mines in this country. The total cost of working for a series of years was under 15s. per ton crude and the mine paid when pig lead was down to £12 per ton. It always carries a large reserve of broken ore underground, which is important to successful mining, and is able to treat 100 tons per day when required to cope with prices.

Too little attention has been paid in the past in this country to working costs above and below ground, and how such can be met in the most efficient way. Lack of development of the ore-bodies and working from hand to mouth, combined with a small output of treatment, lead and zinc-mining in this country is in an unsatisfactory state. It has been a sore point with the average miner that the more he makes on his contract over a certain wage, when the same comes to be re-let the price would in most cases be cut. This has come about by inefficient valuation and not knowing what a worker or workers can do when letting the contract. To my mind no contract should be let on what an individual has done the previous month; the value should be put on the ground to give the worker a living wage from the ground in sight, if he works. I am afraid the managements have done more to kill contract work than the worker himself. Hence the demand for a minimum wage with a go-as-you-please policy. A maximum wage was never too much, but a standard wage irrespective of capacity or intelligence is fatal to all. There are many mines in this country run on modern lines that could show good returns if handled in the right way, and keep capital at home, where it is certainly needed.

As your correspondent was anonymous, I take the liberty of being ditto, and sign myself

INTERESTED.

London, February 18.

Genesis of Cumberland Iron Ores.

The Editor:

Sir—Mr. Kendall, in his letter of January 28, states that I offer no evidence in my letter of December 14 in favour of my conjecture as to the course of geological events in the Lake District. As I said, it is only a conjecture depending on speculative considerations on which we have now and may never have certain knowledge. My conjecture is founded on as little certain knowledge as Mr. Kendall's positive statement that the Carboniferous and later rocks never extended over the Lake District. Perhaps the most that can be said for either view is that it is not impossible.

I am not satisfied with the conclusion Mr. Kendall draws from the facts he states relating to the occurrence of fragments of hematite found in the Permian Breccia near Orebank House, Bigrigg. I do not know if at the time (40 years ago) the possibility of the hematite deposits in the limestone being formed from iron oxide from overlying rocks was in view. Anyone finding fragments of ore in the breccia would naturally conclude they were derived and may not have examined them with special regard to being replacements of limestone fragments. Mr. Kendall states he sliced the fragments 40 years ago for microscopical examination and found no difference between them and pieces taken from the mine, yet some peculiarities in the structure of the fragments from the breccia would, I am advised by geologists, have afforded some evidence as to whether they were derived fragments of hematite or fragments of limestone replaced by iron oxide. The question is too important to be finally decided without the fullest evidence, and I hope Mr. Kendall will pardon me if I say that what was observed so long ago and cannot now be verified does not satisfy me.

It is to be hoped that Mr. Kendall's interpretation is correct as this would open up the probability of hematite being found in the limestone below the Cumberland coalfield in situations where the lines of faulting are known and where deposits might easily be located. My observations in the few cases where the limestone has been proved under and at some distance from the outcrop of the Coal Measures in Cumberland is not in favour of Mr. Kendall's views as to the source of hematite, but this evidence is slight and negative only.

I cannot see any objection to my statement to which Mr. Kendall takes exception that "great light would be thrown upon the genesis and age of hematite deposits by a microscopical examination of the pebbles and fragments found in the Permian Breccia." Perhaps Mr. Kendall thinks that I assume the result would be against his view. One of three results would follow: (a) Found to be derived fragments; (b) found to be replaced fragments of limestone; (c) no evidence either way. As (c) is unlikely, I think I was justified in my statement.

Apart from enclosed fragments of hematite the red staining of the breccia over large areas in the Cleator and Egremont districts is a feature to be noted. This staining appears to be subsequent or secondary. I feel great difficulty in ascribing it to the ascent of iron-bearing solutions or vapours, it is so regular and widespread. It seems more likely to be due to the percolation of water through overlying Trias carrying down iron oxide. The same feature is observed in some parts of the Lancashire coalfield where Carboniferous rocks are stained red for some hundreds of feet in depth where overlain by Trias.

Mr. Kendall seems to think that we might as well suggest a relation between the boulder clay and hematite as between the Trias and hematite, as both formations are found directly overlying deposits of hematite in the limestone. The objections to such a view are: (1) There is not sufficient iron in the boulder clay to account for the masses of hematite in the limestone; (2) boulder clay is not readily permeable to water; (3) in many districts boulder clay is found lying on the limestone with no accompanying deposits of hematite. My contention is that all these conditions are satisfied by the Trias.

In conclusion, my answer to Mr. Kendall's contention that exploration based on a supposed connection between the Trias and hematite in the limestone will result in "a great waste of time and money" has not been met, and I invite him to do so. Even if there is no connection I do not see how the waste comes in.

J. B. ATKINSON.

86, St. George's Terrace,
Newcastle-on-Tyne, February 17.

NEWS LETTERS.

VANCOUVER, B.C.

January 21.

MINERAL PRODUCTION FOR 1920.—In the latter part of January, the Provincial Department of Mines issued the annual preliminary review and estimate of the mineral production of the Province of British Columbia. This report is issued at the commencement of each year for the purpose of placing an approximate estimate before the public, without waiting for the compilation of the actual production, which cannot be completed much before the middle of June. It is understood, therefore, that the figures in the preliminary estimate are subject to revision, but most of them have been found to closely approximate the final figures. The following is the estimate for last year, with the 1919 production, for the sake of comparison:

	1919	1920
Gold, placer..................oz.	14,325	1[illegible],250
Gold, lode....................oz.	152,426	118,176
Silver........................oz.	3,403,119	3,404,926
Copper........................lb.	42,459,339	42,773,660
Lead..........................lb.	29 475,968	21,545,047
Zinc..........................lb.	56,737,651	75,765,268
Coal..................long tons	2,267,541	2,712,228
Coke..................long tons	91,138	68,190

The estimate of the value of the mineral production of last year exceeds the value of the 1919 production by more than two and a quarter million dollars. This increase is due almost entirely to the increased production of coal and zinc. The increase in the production of coal is due very largely to a shortage of fuel-oil during the latter half of the year; a shortage so serious that it necessitated the Imperial Oil Co. closing it refinery, near Vancouver, and the Canadian Pacific Railway converting a number of its oil-burning locomotives into coal-burners. Several coast-going steamships and industrial plants have had to make a similar change. Some idea of how this has increased the demand for coal will be gleaned from the fact that the C.P.R. has had to place an additional order with the Canadian Collieries, Ltd., for 25,000 tons more coal per month. With regard to the zinc figures, it is difficult to see how either those of last year or this year are obtained, unless it is on the assay-value of the ore raised and not on the zinc produced. Whatever the method, it is quite certain that both the 1919 production and the estimate for last year, as given by the Provin-

cial Department of Mines, is fully 45% above the actual production of zinc from British Columbia ores. The Consolidated Mining & Smelting Company produces at least 85% of the zinc made from British Columbia ores, and the company's production was about 26,000,000 lb. in 1919 and 37,000,000 lb. in 1920, as compared with 56,000,000 lb. in 1919, and 76,000,000 lb. given by the local department. There unfortunately is a tendency at times to try to boost output for political reasons, and it looks very much as though that has been the case with the zinc output of the last two years.

As was to be expected, the gold production shows a decrease, the reason for which is quite evident, not only in British Columbia but nearly all over the world. Silver and copper both show an increase in production, but a decrease in value, owing, of course, to market fluctuations. For the same reason the value of the lead production shows an increase, while the production of actual metal shows a decrease. Owing to labour troubles that have tied up the Slocan and Slocan City mines for the greater part of the season, this erstwhile silver district shows a marked falling off in output; fortunately, however, the Dolly Varden and Premier mines, in the north-west section of the Province, have made up the deficit, and the total output is slightly greater than that of the previous year.

Western Canada has not as yet started to try to catch up in building for the four years comparatively idle period during the war, consequently the production of building materials does not show any appreciable increase over that of 1919. Labour prices have been very high, and building materials have been kept at such an exorbitant figure that people have held off reconstruction as long as possible. Just towards the end of the year there was a break in prices of both labour and materials, and considerable activity in building may be looked for during the coming year.

SMELTERS.—The Granby Consolidated Mining, Smelting & Power Company instituted a cut of 75 cents per day in its wage-scale on the first day of the year, and the men agreed to accept it rather than suffer a shut-down, which was the alternative offered to them. Despite the laying-off of some 300 men, Granby is turning out about two and three-quarter million pounds of copper per month: a greater amount than at any time during the past eighteen months. This has been reflected on the shares of the company, which have advanced 10 points above the mini- of 15 reached during November.

The Consolidated Mining & Smelting Company has cut day wages 55 cents per day and those paid by the month $15 per month. The company has an enormous stock of metals on hand, and, as a consequence, has had to notify individual mine-owners that it is no longer able to pay cash for metal contents of ores received, but can give only warehouse receipts. This, it is feared, will mean the closing of a number of the small interior mines, as freight-rates prohibit shipment to smelters in the United States. Probably 85% of the ore treated at Trail comes from the Consolidated Company's own mines, and the output of these is being maintained. During last year some 60,000 tons more ore was treated at Trail than in 1919, and metallurgically, that is with regard to high extraction, it is said to be the best year that the company ever has had. Only a small quantity of copper ore is being treated at Trail, so that Granby may be said to be practically the only copper producer at the present time.

COAL PRICES.—The boards of trade of the big cities have demanded a Government inquiry into the price of coal, the high price of which is checking industry in the Province. In Victoria and Vancouver, according to quality, coal ranges at from $13 to $15 per ton, while in its official estimate the Department of Mines places the price at the pit's mouth at $5. As it is only about an 80-mile haul by water from the Nanaimo mines to Victoria and less to Vancouver, the middlemen appear to be profiteering pretty extensively. No great cut can be made at the pit's mouth, as a majority of the companies have wage-agreements with the men that do no expire until the end of next year.

DOLLY VARDEN.—The Taylor Mining Company has completely closed the Dolly Varden mine for the winter, the directors of the company having decided that, as it is likely that there will be a considerable reduction in the cost of wages next year, it would be cheaper to push development at the same time as production next spring, as it is impossible to ship during the winter months on account of the heavy snows blocking the railways.

VANCOUVER ISLAND COPPER.—The Tidewater Copper Co., which has been developing a property and installing machinery at Sidney Inlet, Vancouver Island, for the past three years, shipped its first consignment of 400 tons of concentrate to the Tacoma smelter last December. Although nothing has been announced, evidently the return from the consignment was found to be insufficient to guarantee the continuance of production with cop-

per at its present price, for the concentrating plant has been closed down, but the development of the mine is being continued.

PREMIER.—The winter shipping at the Premier mine, in the Salmon River district, is progressing favourably, 850 tons of ore, running $400 per ton, already having been shipped, while another 500 tons will be sent to the Tacoma smelter by the next boat. A survey is now being made for an aerial tramway from the mine to tide-water, and when this is completed the Premier will be able to ship throughout the year. The Algunican Development Company will commence to ship ore from the Spider mine early in February. This will make the second shipping mine in the Salmon River district. The ore is a complex one, containing sulphides of zinc, lead, copper, and iron, and is rich in native and ruby silver, some of it running several thousand ounces per ton. About 100 tons of such ore will be shipped during the winter.

IRON ORE.—British engineers have been investigating the iron-ore resources of the Province for the past four months, and it is stated that steps will be taken toward the founding of an iron and steel industry in the neighbourhood of Vancouver during the present season.

TORONTO.

February 10.

PORCUPINE.—The output of gold has been greatly curtailed by reason of the shortage of electric power, which is likely to continue for a few weeks longer until the breaking up of winter brings relief. As soon, however, as power is available a great expansion in the mining industry seems assured, as several properties now closed will be reopened and new companies are preparing to enter the field. At the Dome Mines an important discovery of rich ore has been made at the 1,050 ft. level, where several large ore-bodies have been encountered. Much of the ore will run as high as $20 per ton. The mill is now only working at about one-third capacity. The shareholders of the Davidson Consolidated have decided to sell the property to an English syndicate, which has purchased 1,000,000 shares of the treasury stock at 75c. per share and will buy the stock outstanding in the hands of shareholders at $1·18 per share. Mr. Rowland C. Feilding, consulting engineer, who examined the mine for the British interests, estimates the tonnage of ore disclosed by the work done including probable ore at 350,000 tons averaging $11 per ton recoverable. The mine will be reopened about March 1, and it is intended to erect a 500 ton mill. The annual financial statement of the Porcupine Crown shows profits of $28,788 which, added to the balance carried forward, makes a surplus of $242,532. Milling operations were obliged to be discontinued and development much restricted owing to power shortage. The Premier Paymaster, formerly the Standard, which has been closed for some time after about $100,000 had been expended upon it, is to be reopened, having been financed by Boston capital. The shaft, now down 200 ft., will be sunk to the 500 ft. level. A large ore-body has been developed at the 200 ft. level. The Porcupine Associated Goldfields, Ltd., has been organized, capitalized at $5,000,000, to operate a large group of mining claims in the eastern part of the field. Among the properties included in their holdings are the La Palm and Three Nations, on which a good deal of work has been done, and the Jermy Veteran claim. Altogether the company will control about 720 acres. A large block of the stock is being underwritten by an English syndicate. Negotiations are in progress looking to the amalgamation of the West Dome and the Dome Lake. As the veins of the Dome Lake run into the West Dome it is proposed to work both properties through the Dome Lake shaft. The long-disputed question as to whether the mills of the mining companies were liable to municipal taxation has been finally settled by a decision of the Supreme Court of Ontario, declaring them exempt. As the properties involved in the Porcupine district are valued at about $2,000,000 the matter is of considerable importance to the mining companies.

KIRKLAND LAKE.—The power situation is not so serious here as in the other mining camps, but the supply of electric energy is by no means equal to requirements. The position of the Lake Shore has been greatly improved by development on the 200 ft. and 400 ft. levels, which have been opened up for 2,000 ft. and 1,000 ft. respectively, encountering a large ore-body which is stated to rank with the Porcupine deposits in size and to show higher enrichment. The mill during December treated 1,865 tons of ore for a yield of $34,670. The Wright-Hargreaves mill, with a capacity of 150 tons per day, has been completed and will be put in operation as soon as power can be obtained. The company is expected to be one of the largest producers of the district. The Ontario Kirkland is developing a good shoot of high-grade ore which has been opened up for about 100 ft. on the 450 ft. level. The vein also carries galena, chalcopyrite, and molybdenite. A min-

ing plant is being installed on the Wood-Kirkland and work will shortly be resumed. The vein at a depth of 100 ft. is 4 ft. wide, carrying good commercial ore. At the Hunton-Kirkland rich ore showing visible gold has been encountered in the shaft at a depth of 95 ft. The King-Kirkland has installed a mining plant. A shaft is down 40 ft. on a promising vein. The Kirkland Lake mine during December produced approximately $300,000 in gold. Development is in progress on the 400, 700, and 900 ft. levels. Exploration work is being undertaken on the 400 ft. level to open up the western part of the property where a second ore zone is believed to occur. The capacity of the mining equipment of the Bidgood is being doubled preparatory to the resumption of operations on a large scale. The shaft will be put down from 300 ft. to deeper levels.

COBALT.—With the arrival of spring a general resumption of activity on many of the smaller properties, where operations have been suspended or temporarily curtailed, is anticipated. The lower wage scale which comes into force on the 15th, involving an all-round reduction of 75c. per day, will be an important factor in restoring normal conditions. During December the Nipissing produced silver to the estimated value of $139,882 and cobalt valued at $18,200. The company is in a strong financial position, with cash and bonds in hand to the amount of $3,432,201, and ore and bullion valued at $1,488,802, making a total of $4,921,010. The Kerr Lake has secured an option on the two Hargraves claims adjoining, which will be worked from the Kerr Lake shaft at the 375 ft. and 425 ft. levels. The annual report of the Crown Reserve is a disappointing one, as owing to adverse conditions development had to be discontinued, resulting in a deficit of $72,055. The diamond-drilling campaign, carried on to a depth of 1,500 ft., will be continued to 2,500 ft. An important strike has been made on the first level of the University property of the La Rose, where a vein 2 in. in width carries high-grade ore in addition to milling ore of a good width. At the Bailey a recently discovered vein is being followed up and shows good milling ore over a width of 3 to 4 ft. with some patches of high-grade ore. The Ruby was driven for about 100 ft. on the 110 ft. level, on a vein which has widened to 18 in. and carries native silver, with well-mineralized wall-rock. A new company, the Primo Silver-Cobalt Mining Co., Ltd., has been formed with an authorized capital of $1,000,000 to operate the Barber property, about a mile and a half west of the Montreal River and some ten miles west of the producing area of the camp. The property contains several veins having low silver content and a high percentage of cobalt metal. A mining plant has been purchased.

THE MACKENZIE RIVER OIL FIELD.—The discovery by the Imperial Oil Co. of oil in the Mackenzie River district, close to the Arctic circle, created much excitement and led to the taking up of extensive areas in Western Canada. A rush of prospectors to the north would have taken place but for the action of the Government, which, fearing a repetition of the hardships and disasters attendant upon the gold rush to the Yukon in '98, issued orders that all prospecting parties which were not well provisioned and supplied to encounter the rigours of an Arctic winter should be turned back by the Mounted Police. This has more recently been followed by an Order in Council suspending the negotiations for the disposal of oil lands in the North-West. This is merely a temporary measure to give the Government an opportunity to consider the whole situation in the North-West and adopt a permanent policy in regard to oil development, which it is expected will be made public in a few days. In the meantime the Imperial Oil Co., which had laid out an extensive programme for this season's operations, is holding it in abeyance until the new regulations are promulgated.

MELBOURNE.

January 10.

TASMANIAN OIL-PROMOTIONS.—Owing to exaggerated statements issued by promoters in connection with the so-called oilfields in the Barn Bluff and Pelion areas, Mr. Loftus Hills, Government Geologist, has found it advisable to address a report on the subject to the Secretary of Mines. We quote Mr. Hills in full herewith.

"I would first wish to bring under your notice that statements have been attributed to an officer of the Geological Survey which are not in accordance with the conclusions arrived at and the wording of his report. The article referred to appeared in the *Zeehan and Dundas Herald* of November 30, and was, I believe, copied from the Melbourne *Age* of some days earlier. The article in question contains the following: 'It has been estimated by the Assistant Government Geologist of Tasmania that there are nearly 4,000,000 tons of material very rich in oil and wax.' The only statement published by the Geological Survey in connection with the Barn Bluff coalfield of recent date

is that by Mr. A. McIntosh Reid, in Geological Survey Bulletin No. 30, pages 75-80. Mr. McIntosh Reid does not make the statement that there are nearly 4,000,000 tons of material rich in oil and wax. What Mr. Reid has stated is as follows: 'The quantity of pelionite in the Barn Bluff area has been put at approximately 1,700,000 tons, and that of the second grade cannel is estimated at 2,200,000 tons.' In describing the properties of the pelionite in regard to oil production, the only statement made by Mr. Reid was that the distillation test by Mr. W. F. Ward, Government Analyst, showed that pelionite contained 92 gallons of oil and tar per ton of coal. As the report appearing in the press makes Mr. Reid appear to state that there are nearly 4,000,000 tons of material rich in oil and wax, there is clearly a misrepresentation which is apt to mislead the public.

" I further desire to draw your attention to the fact that a great number of the articles that have appeared in the press within the last few days contain assertions that the material, which they term 'albertite,' occurring in the Barn Bluff field, and the general geological features of the country, are indications of the existence of liquid oil, and it is proposed to raise capital to carry out boring operations. While not desiring in any way to interfere with the investigations of our natural resources, I consider it my duty to draw attention to what are really mistaken ideas in regard to the possibility of the discovery of oil in this area. There is a very great attraction to the general public in the possibility of striking oil, and it would be a most regrettable thing if money were subscribed and wasted on carrying out boring operations in an area where there is no chance of striking liquid oil. The main reason adduced in favour of Barn Bluff area as an oilfield is the so-called discovery of albertite. In the first place, this is not a discovery, as the substance was discovered about thirty years ago. It is described in several publications of the Geological Survey as pelionite, and it is shown in Bulletin No. 13 of the Geological Survey that it is a variety of sapropelic coal. It has since been demonstrated that this substance occurs in practically horizontal beds of Permo-Carboniferous age, and the geological data in connection with this are contained in Bulletin No. 30 of the Geological Survey. All of these sapropelic coals have kerosene-like products, together with more or less tar on being subjected to distillation. The fact that this pelionite, which has been referred to as albertite in the recent press paragraphs, gives oils on distillation is no fresh discovery, and of no special significance. In fact, the kerosene shale of Preolenna and the other sapropelic coals occurring in that district have been demonstrated to yield a similar proportion of crude oil on distillation. The two occurrences are in fact on the same geological horizon, and of the same general geological character. If, therefore, there is to be any attention paid to the possibility of liquid oil, the first investigation should be that of the accessible Preolenna district rather than the very remote Barn Bluff districts. One is tempted to conclude that the very remoteness of the Barn Bluff deposits has lent enchantment to the proposition.

" On the geological evidence in the possession of the Geological Survey, there is no more chance of finding liquid oil in the Barn Bluff-Pelion area than in the Preolenna district. It is further the opinion of the Geological Survey, based on the knowledge of the geological structure, and the geological history of Tasmania acquired during the investigations of the last thirty years, that the conditions essential for the formation and existence of an oil-field do not occur in either of these districts. The reference to pelionite as the mineral albertite is misleading, as albertite occurs in nearly vertical fissures, and is inspissated petroleum, whereas pelionite is a defined coal bed from which the volatile matter has not been distilled. Investigation of the Barn Bluff-Pelion area from the point of view of its potentialities as a coalfield is a justifiable and a very desirable undertaking, but I consider it my duty to point out that money spent in the hope of locating liquid oil will be surely wasted. The persons responsible for the paragraphs recently appearing in the press, and the claims made therein, must produce more evidence pointing to the possibility of finding liquid oil than the reasons put forth up to the present. In the absence of such more definite indications, I am compelled, by a realization of my duty to the general public, to warn them that on the evidence in our possession there is no hope of any discovery of liquid oil in the Barn Bluff-Pelion area."

PROSPECTING FOR COAL IN TASMANIA.—The George Town Coal Prospecting Association has been formed in Launceston to prospect a coal-bearing belt adjacent to the proposed deep-water port at Bell Bay, on the Tamar. A boring machine, supplied by the Government Geologist, Mr. Loftus Hills, and used during the war on the Western front, is being utilized for the purpose of testing the belt. Small seams have been discovered, and

certainly the coal possesses excellent qualities, in fact, equal to anything that has so far been discovered in the State; but the bore alone will reveal whether the seams will develop to such an extent as to warrant the opening up on an extensive scale. Mr. Loftus Hills considers that the coal-bearing nature of the country is well worthy of a thorough test.

NORTH-EAST TASMANIA.—The restricted water supply has caused mining operations throughout the north-eastern district of Tasmania to ease off. The recent slump in the tin market will affect prices very considerably, and the higher prices ruling for all mining requisites, as well as labour, are having a deterrent effect on mining generally. At the Briseis mines sluicing operations have been proceeding at Krushka's Flat main face and also at the Ringarooma high-level drift face, but owing to the shortness of water the latter work has been suspended for the present. Krushka's Flat tin face is looking well. The drainage water is now considerably less, and there is no trouble from that source now, nor will be during the summer months. Preparations for turning the river are in progress, but it will most likely be a year or two before this is accomplished.

PERSONAL.

A. W. ALLEN has been appointed associate editor of the *Mining and Scientific Press*.

D. H. ANGUS has been appointed manager of the Bidgood mine, Kirkland Lake.

J. A. BANCROFT, professor of geology at McGill, is serving for a year as assistant general manager of the Anyox copper mines of the Granby Consolidated Company.

W. J. BARNETT has left for Spain.

H. BERTRAM BATEMAN is back from Arabia.

A. CHASTON CHAPMAN has been appointed president of the Institute of Chemistry.

DR. J. MACKINTOSH BELL has returned to Ontario.

FRANK COGILL has left for West Africa.

C. V. CORLESS is nominated for the presidency of the Canadian Institute of Mining and Metallurgy.

E. H. CUNNINGHAM CRAIG has been making a report on the properties of the Oilfields of Egypt.

G. D. DELPRAT has resigned the general managership of the Broken Hill Proprietary and is succeeded by ESSINGTON LEWIS. Mr. Delprat preserves his connection with the company as consulting engineer.

HENRY S. DRINKER has been made an honorary member of the American Institute of Mining and Metallurgical Engineers. He is one of the original members, and he attended the organization meeting in 1871.

P. ROSS FRAMES is here from South Africa.

CHARLES W. GOODALE is to be presented with the gold medal of the Mining and Metallurgical Society of America.

H. A. GUESS has gone to South America for the Guggenheim interests.

SIR ROBERT HADFIELD has been awarded the John Fritz Medal.

WILLIAM HOSKING is the new president of the Cornish Institute of Engineers.

OWEN LETCHER has been appointed editor of the *South African Mining & Engineering Journal*.

T. H. MOTTRAM has been appointed Chief Inspector of Mines for the United Kingdom.

C. H. MUNRO has returned to the Federated Malay States from America.

C. T. NICOLSON, of the Bucyrus Company, is back from the United States.

R. H. RASTALL, lecturer on economic geology at Cambridge and editor of the *Geological Magazine*, has taken the degree of Doctor of Science in Cambridge University.

J. B. RICHARDSON is back from Bolivia.

J. H. RONALDSON is on his way home from Australia.

EDGAR F. SMITH is the new president of the American Chemical Society. It is worthy of note that he was president of this society twenty-five years ago. He is well known in this country as the author of the book on Electro-Analysis.

D. A. THOMPSON has left for West Africa.

G. H. THURSTON is back from West Africa.

PROFESSOR THOMAS TURNER will deliver the annual May lecture before the Institute of Metals.

T. WEIR is expected from the Bongwelli, Nigeria.

J. S. WETZLAR, the London managing director of the Consolidated Mines Selection Company, has left for South Africa.

W. R. WHITNEY, director of the research laboratory of the General Electric Company, at Schenectady, New York, has been awarded the Perkin Medal.

M. Y. WILLIAMS, of the Canadian Geological Survey, has been appointed professor of paleontology in the University of British Columbia.

J. H. G. WILSON has been appointed manager of the Akim Alluvials, and left England on February 16.

L. B. WOODWORTH has been elected president of the South African Institute of Electrical Engineers.

FERGUS L. ALLAN, manager of the Mexico Mines of El Oro, died in November last.

EWEN CATTANACH, a director of the British Platinum and Gold Corporation, died on February 21.

G. A. PRENTICE died on February 20. He was a notable figure in Stock Exchange circles, particularly in the South African market.

FREDERICK WALKER died on February 18. He was a London solicitor and took part in many successful resuscitations of mining companies that had got into difficulties.

C. F. H. LESLIE, at one time chairman of the Kyshtim Corporation and of the Messina (Transvaal) Development Co., died last month. In early days he was a distinguished cricketer, playing for Oxford and Middlesex, and being a member of one of the English teams visiting Australia.

FREDERICK CLOSE died of tubercular trouble in Switzerland last month. He was a mining engineer of varied experience. He did a great deal for the flotation process in early days. Later he was manager of gold mines in Sumatra. His article in the MAGAZINE a few years ago on the mining developments behind Juneau, Alaska, showed his sagacity of judgment.

G. J. SNELUS died on January 21 at the Jos Hospital, Nigeria, of blackwater fever. Mr. Snelus was serving his first term in Nigeria, whither he proceeded in December, 1919, to take up the assistant managership of the Kaduna Syndicate, Ltd., and Kaduna Prospectors, Ltd., while the manager, J. E. Snelus, his brother, was on leave. He had served in many parts of the world before going to West Africa, and he was particularly well

known on the Continent. From 1895 to 1900 he was in Belgium with the Société John Cockerill, Seraing, Liége, and from there he went to France for two years. He then returned to England, and worked as an inspector of iron and steel. Subsequently he worked in New Caledonia, Spain, Canada, and Cornwall. From 1912 to 1919 he was in Madagascar on gold and graphite prospecting and on land irrigation work. During the war he was British Vice-Consul at Majunga, Madagascar. He was born at Dowlais, Glamorgan, in 1869, and was the eldest son of the late G. J. Snelus, the distinguished steel metallurgist.

TRADE PARAGRAPHS

LOW & BONAR, LTD., of Dundee, send us their chart showing the monthly prices of raw jute and hessian cloth during the past six years.

THE CARBORUNDUM CO., LTD., of Trafford Park, Manchester, send us Catalogue No. 6, dealing with manufactures of carborundum and aloxite, used for grinding and abrasive purposes.

HYATT, LTD., of Thurloe Place, South Kensington, London, S.W.7, send us a new pamphlet describing fully the application of Hyatt Roller Bearings to industrial trucks and trollies.

THE METROPOLITAN-VICKERS ELECTRICAL CO., LTD., of Manchester, send us two pamphlets. One of these, No. 7855/1B, describes buffing motors, and the other, No. 7974/2A, deals with the electrical equipment of cinematograph theatres.

JOHN & EDWIN WRIGHT, LTD., of the Universe Rope Works, Birmingham, are well represented at the British Industries Fair, held at Birmingham. They have a special show of steel ropes used in mine haulage, aerial ropeways, and for oil-well drilling purposes.

GUTHRIDGE, LTD., of Sydney, have recently made further improvements in their "Curvilinear" concentrating table. This table is small but of large capacity. The London agents are James Smith & Partners, Ltd., of 36, Camomile Street, E.C.3, who will supply pamphlets and other information on application.

G. A. HARVEY & CO. (LONDON), LTD., of Suffolk House, Laurence Pountney Hill, London, E.C.4, and Woolwich Road, S.E.7, inform us that their Galvanized Tank List No. 225 is now subject to 60% discount instead of 55% as hitherto; also that their galvanizing rates have been reduced 10%, that is, tariff rates are now being charged without any addition.

THE SULLIVAN MACHINERY COMPANY, of Chicago, and Salisbury House, London, E.C.2, are now giving displays of their cinema show in England. Particulars of this interesting enterprise were published in the MAGAZINE for July, 1920. The pictures give a vivid record of the business of a machine shop where drills and coal-cutters are made, and of the doings of the coal-cutters underground. They might to advantage be shown in coal-mining centres in this country, where they cannot fail to have considerable educative influence, for they show why American coal is mined cheaply.

We have received catalogues from a number of firms making ACETYLENE LAMPS suitable for the purposes of the mining engineer. These names will be of use to many of our readers, so we give them herewith: CARBIC, LTD., 51, Holborn Viaduct, London, E.C.1; THORN & HODDLE ACETYLENE CO., LTD., 151, Victoria Street, Westminster; ALLEN-LIVERSIDGE, LTD., 106, Victoria Street, Westminster; THE PHOS COMPANY, Dalston Lane, London, E.8.; THE WOLF SAFETY LAMP CO., Star Works, Sheffield; and THE PREMIER LAMP & ENGINEERING CO., LTD., Moorfield Works, Wortley, Leeds.

THE HARDINGE COMPANY announces that, owing to expanding business, it has removed its London offices to larger premises at 11, Southampton Row, W.C.1 Satisfactory arrangements have now been made for manufacturing in England on a much greater scale in order to ensure prompt deliveries. The latest design of Hardinge mill embodies important new features, ensuring rapid feed and discharge of large tonnages for both wet and dry grinding. The company has recently issued two new pamphlets, one dealing with the application of the Hardinge mill to the grinding of cement clinker, and the other to the grinding of foundry waste and the reclamation of brass and other metal therefrom.

NOBEL INDUSTRIES, LTD., of 6, Cavendish Square, London, W.1, send us particulars of their exhibit at the British Industries Fair, Birmingham. The details of the exhibit are as follow: Hardware products: metals and metal fittings, Kynoch lanterns and stoves, power presses, thermit welding, metal alloys; ammunition: cartridges by Eley, Kynoch, and Nobel, smokeless powders, components; incandescent mantles: ironclad, shocking machine; bicycles: "all-weather" and "speed" models, 1921 improvements, transfer machine; industrial collodions: "Necol" products, cements, varnishes, lacquers, textile stains. Circulars and other printed matter relating to the foregoing and also to mining and other explosives will be sent on application to the firm's advertising department at 5, Palace Street, London, S.W.1.

METAL MARKETS

COPPER.—The position in copper so far as the fundamental factors are concerned has really not altered during the past few weeks. That is to say, the stocks of the metal still remain more than abundant, while consumption is at a very unsatisfactory rate. An event of some interest recently was the arrangement carried through in the United States between the Copper Export Association and a syndicate headed by the National City and Guaranty companies, whereby some 400,000,000 lb. of copper was financed. Against this bankers were offering 40,000,000 dollars of 8% notes with the copper as collateral. This metal has therefore been set aside as exportable surplus, and a good deal was made of the fact at the time by those interested in getting prices higher. In the long run it has had little effect upon the situation. According to reports to hand from America recently, copper production is being pared down to the lowest limit. The January output figures of several leading mines show that current production is just about 50% of the 1917 rate. This reduction of output must affect the situation in the end. The standard market in London showed some tightness at one time so far as positions maturing up till April were concerned. This was brought about by the covering of bears or possibly of others who had sold short in standard against purchases of refined. These shorts seemed to become somewhat nervous on the report that some American buying had been done here, but after the more pressing demand was satisfied values eased off again. It is understood that with the return of a further section of the miners, the strike at the Rio Tinto mines is now completely over.

Average prices of cash standard copper: February 1921, £71. 0s. 9d.; January 1921, £71. 1s. 4d.; February 1920, £120. 6s. 2d.; January 1920, £118. 4s. 1d.

TIN.—This market continues to fluctuate without any very definite tendency. So far as the consuming industries are concerned, business is very unsatisfactory. The demand from America has been very disappointing, while little can be expected to be done with home

DAILY LONDON METAL PRICES: OFFICIAL CLOSING
Copper, Lead, Zinc, and Tin per Long

COPPER

Feb.	Standard Cash £ s. d. £ s. d.	Standard (3 mos.) £ s. d. £ s. d.	Electrolytic £ s. d. £ s. d.	Wire-Bars £ s. d. £ s. d.	Best Selected £ s. d. £ s. d.
10	[illegible] [illegible] 0 to 72 0 0	72 5 0 to 72 7 6	78 0 0 to 80 0 0	78 0 0 to 80 0 0	76 10 0 to 77 10 0
11	71 7 6 to 71 10 0	71 15 0 to 71 17 6	78 0 0 to 79 10 0	78 0 0 to 79 10 0	76 0 0 to 77 0 0
14	71 0 0 to 71 5 0	71 7 6 to 71 10 0	77 10 0 to 79 0 0	77 10 0 to 79 0 0	76 0 0 to 77 0 0
15	71 12 [illegible] to 71 15 0	71 12 6 to 71 15 0	77 0 0 to 78 0 0	77 0 0 to 78 0 0	75 0 0 to 76 0 0
16	72 5 0 to 72 10 0	71 12 6 to 71 17 6	76 0 0 to 78 0 0	76 0 0 to 78 0 0	75 0 0 to 76 0 0
17	[illegible] [illegible] [illegible] to 73 10 0	71 10 0 to 71 15 0	76 0 0 to 77 0 0	76 0 0 to 77 0 0	75 0 0 to 76 0 0
18	73 5 0 to 73 7 6	71 0 0 to 71 5 0	76 0 0 to 77 0 0	76 0 0 to 77 0 0	74 0 0 to 76 0 0
21	72 5 0 to 72 10 0	70 10 0 to 70 15 0	75 0 0 to 77 0 0	75 0 0 to 77 0 0	74 0 0 to 76 0 0
22	70 15 0 to 71 0 0	69 17 6 to 70 2 6	74 0 0 to 76 0 0	74 0 0 to 76 0 0	73 0 0 to 75 0 0
23	70 15 0 to 71 0 0	70 0 0 to 70 5 0	74 0 0 to 76 0 0	74 0 0 to 76 0 0	73 0 0 to 75 0 0
24	[illegible] [illegible] 0 to 70 5 0	69 5 0 to 69 10 0	73 10 0 to 75 10 0	73 10 0 to 75 10 0	73 0 0 to 75 0 0
25	[illegible] [illegible] [illegible] to 69 10 0	68 5 0 to 68 10 0	73 0 0 to 75 0 0	73 0 0 to 75 0 0	71 10 0 to 73 10 0
28	68 5 0 to 68 10 0	67 10 0 to 67 15 0	73 0 0 to 75 0 0	73 0 0 to 75 0 0	71 10 0 to 73 10 0
Mar.					
1	68 5 0 to 68 10 0	67 15 0 to 68 0 0	73 0 0 to 74 10 0	73 0 0 to 74 10 0	71 0 0 to 73 0 0
2	67 10 0 to 67 15 0	67 5 0 to 67 10 0	73 0 0 to 74 0 0	73 0 0 to 74 0 0	71 0 0 to 73 0 0
3	67 12 6 to 67 15 0	67 7 6 to 67 10 0	73 0 0 to 74 0 0	73 0 0 to 74 0 0	71 0 0 to 73 0 0
4	66 15 0 to 67 0 0	67 5 0 to 67 10 0	72 0 0 to 73 0 0	72 0 0 to 73 0 0	69 0 0 to 71 0 0
7	66 0 0 to 66 2 6	66 5 0 to 66 10 0	71 0 0 to 72 0 0	71 0 0 to 72 0 0	69 0 0 to 71 0 0
8	66 0 0 to 66 5 0	66 5 0 to 66 10 0	71 0 0 to 72 0 0	71 0 0 to 72 0 0	68 0 0 to 70 0 0
9	65 10 0 to 65 15 0	66 0 0 to 66 5 0	70 0 0 to 71 0 0	70 0 0 to 71 0 0	68 0 0 to 70 0 0

consumers in view of the slack conditions prevailing in the South Wales tinplate industry. A certain amount of inquiry has been seen from the Continent, and a fair amount of business has resulted, mostly apparently in Banka tin. Generally speaking, however, the outlet for the metal among actual users has been small. Meanwhile the standard tin market remains based virtually upon the stocks of Chinese and English tin which are in this country, other brands such as Straits, Banka, Billiton, and Australian metal all commanding premiums. In the middle of the month the Federated Malay States Government reduced the "pegged" price from 115 dollars to 100 dollars per picul. The reduced figure equalled something like £204 for the tin landed here, which therefore was still above the level of the market in this country, and business consequently continued suspended in that quarter. At the end of February the peg was withdrawn altogether, and this had a somewhat depressing effect on the market here. It is understood that the Federated Malay States Government do not intend sacrificing the stocks they have accumulated, but when they will be able to sell them at a profit is hard to say. Batavia has also been reserved, but China has sold from time to time. The net result of these price-pegging policies is that supplies of the metal tend to accumulate, and are apt to become a menace to the market in the future. Meanwhile, in other directions output is being cut down. The Cornish mines, in consequence of the continued fall in the price of tin, wolfram, and arsenic, have suspended operations. What is more important from the market point of view is that cables from Bolivia say that mine-owners there have put into force a sharp cut in production. The January exports were only 1,400 tons (reckoned in fine tin), while those for February, March, and April are only expected to average 700 tons (fine) per month.

Average prices of tin: February 1921, £166. 9s. 1d.; January 1921, £190. 13s. 11d.; February 1920, £395. 16s. 6d.; January 1920, £376. 12s. 8d.

LEAD.—Values of this metal declined materially during the month of February, the price having indeed come to within measurable distance of an ordinary pre-war level. In this respect lead was somewhat of a laggard, the other non-ferrous metals having come already to such prices as usually ruled prior to the war. Probably the value is now below the average cost of production, but with the consumption very unsatisfactory and stocks accumulating the consequent liquidation had the inevitable effect. Business with users, as already indicated, has been very unsatisfactory. At one time the cable-makers took fair quantities, but latterly this tended to ease off, although the decrease may have been partly off-set by an improvement in some other lines. Generally speaking, however, the aggregate consumption is poor. It is understood that production in Spain is being curtailed to some extent by the stoppage of some mines, but it is generally believed that the bigger concerns continue operating, no doubt with the object of keeping their staffs together and preventing unemployment. It is believed that there is a stock of lead in Spain amounting to something like 32,000 tons, though this figure cannot be confirmed. Arrivals continually come in here from that quarter, but it is doubtful if producers are doing more than getting rid of their current production. The production in America last year increased, and business in the consuming industries in that country is apparently very unsatisfactory. Consequently prices there have eased off, the last Trust price quoted being 4·10 cents. It would not, therefore, be surprising to see additional quantities coming forward from that quarter to Europe before long. Meanwhile, owing to the fire at the Port Pirie refinery, Australia is almost out of the picture as a producer. This would be serious were consumption normal, but present supplies are sufficient apparently without shipments from there.

Average prices of lead: February 1921, £21; January 1921, £23. 12s. 6d.; February 1920, £50. 12s. 9d.; January 1920, £47. 7s. 1d.

SPELTER.—This market has been showing a moderately steady tendency recently, the fluctuations being really only of a minor character. The general situation shows little material alteration. Business with consumers still remains very unsatisfactory, and, although at times there are signs of inquiry waking up a little bit, this is seldom sustained. Some demand, however, has been seen from the East and metal has been sold for shipment from here to Japan. America has not continued her buying policy here, owing no doubt to the improvement in the rate of dollar exchange, coupled with the easing of the price in America having

PRICES ON THE LONDON METAL EXCHANGE.
Tons; Silver per Standard Ounce; Gold per Fine Ounce.

Lead: Soft Foreign	Lead: English	Zinc (Spelter)	Standard Tin: Cash	Standard Tin: 3 mos.	Silver: Cash	Silver: Forward	Gold	
£ s. d. £ s. d.	£ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.			s. d	Feb.
22 0 0 to 22 10 0	23 15 0	26 0 0 to 27 0 0	165 0 0 to 165 5 0	170 0 0 to 170 5 0	36⅛	34¾	105 10	10
21 5 0 to 22 0 0	23 0 0	25 0 0 to 26 0 0	168 0 0 to 168 5 0	172 10 0 to 172 5 0	36¼	34⅝	105 6	11
20 15 0 to 21 12 6	23 0 0	24 15 0 to 25 15 0	172 0 0 to 172 5 0	175 10 0 to 176 0 0	35¾	34	105 6	14
21 5 0 to 22 0 0	23 0 0	24 17 6 to 25 12 6	170 5 0 to 170 10 0	173 10 0 to 174 0 0	34⅛	34⅛	105 1	15
20 15 0 to 21 10 0	22 10 0	24 15 0 to 25 15 0	163 0 0 to 163 10 0	167 10 0 to 168 0 0	34	33¾	104 7	16
20 0 0 to 20 12 6	22 0 0	24 12 6 to 25 12 6	168 0 0 to 168 10 0	172 0 0 to 172 10 0	34¾	34¼	104 11	17
20 0 0 to 20 10 0	22 0 0	25 10 0 to 26 5 0	173 10 0 to 174 0 0	176 10 0 to 177 0 0	33⅞	33½	105 6	18
19 5 0 to 20 5 0	21 10 0	25 10 0 to 26 5 0	170 0 0 to 170 5 0	173 10 0 to 173 15 0	33	32⅞	106 0	21
19 0 0 to 19 15 0	21 10 0	25 2 6 to 25 12 6	170 0 0 to 170 10 0	173 0 0 to 173 10 0	33¾	33⅝	105 6	22
18 10 0 to 19 7 6	20 15 0	25 7 6 to 26 0 0	169 0 0 to 169 10 0	172 10 0 to 173 0 0	32¾	32¼	105 8	23
18 5 0 to 19 0 0	20 10 0	25 10 0 to 25 15 0	168 10 0 to 169 0 0	171 15 0 to 172 0 0	32	32	105 11	24
16 10 0 to 17 5 0	19 0 0	23 15 0 to 24 15 0	165 10 0 to 166 0 0	169 10 0 to 170 0 0	31⅜	31⅜	106 4	25
17 10 0 to 18 2 6	19 10 0	23 15 0 to 24 10 0	159 10 0 to 160 0 0	163 10 0 to 164 0 0	33	32½	106 1	28
								Mar.
17 10 0 to 18 5 0	19 10 0	23 15 0 to 24 15 0	158 0 0 to 159 0 0	162 0 0 to 162 10 0	32½	32	105 10	1
18 5 0 to 19 0 0	20 0 0	23 10 0 to 24 15 0	155 10 0 to 156 0 0	159 10 0 to 160 0 0	31½	31	105 8	2
18 15 0 to 19 7 6	20 10 0	23 12 6 to 24 17 6	154 15 0 to 155 0 0	158 0 0 to 158 10 0	31¾	31¼	105 7	3
18 12 6 to 19 5 0	20 10 0	23 12 6 to 25 2 6	153 0 0 to 153 10 0	156 10 0 to 157 0 0	31⅛	30¼	105 [illegible]	4
18 2 6 to 18 15 0	20 0 0	24 5 0 to 25 15 0	153 0 0 to 153 10 0	156 10 0 to 157 0 0	31½	30¾	105 [illegible]	7
18 0 0 to 18 7 6	19 10 0	26 5 0 to 26 10 0	150 15 0 to 151 5 0	154 10 0 to 155 0 0	31¼	30⅞	105 6	8
18 5 0 to 18 12 6	19 10 0	26 15 0 to 26 15 0	148 0 0 to 148 10 0	151 0 0 to 151 10 0	31⅝	30¾	105 11	9

made such business unprofitable. Germany sells here from time to time, and in view of the amount of metal that has been sold here by that country the market may be said to have held up very well considering the fact that consumers are taking so little. There still seems to be a good deal of metal to come forward from Germany, and it remains to be seen whether the market here can absorb this without prices suffering. Belgium does not offer very much, and is considerably reducing production. It is expected that by March the production will only amount to about 4,000 tons, or half the December output. Were trade anything like normal the existing supplies of spelter would no doubt get quickly used up, as there is certainly no superabundance for normal times, but with industry everywhere as stagnant as it has been, there is more than enough for present requirements.

Average prices of spelter: February 1921, £25. 5s. 5d.; January 1921, £25. 15s. 7d.; February 1920, £62. 3s. 6d.; January 1920, £59. 10s. 4d.

ZINC DUST.—There is little fresh to report regarding this market, which continues very quiet. High-grade Australian stands at about £70 to £80 per ton, with American at £65, and English at £75. Continental material can be had at lower figures.

ANTIMONY.—English regulus continues at £37 to £40 for ordinary brands, and at £38. 5s. to £42 for special brands. Foreign regulus has been quiet. Down to £23 c.i.f. has been done for shipment from the East.

ARSENIC.—Business continues very idle, and the current quotation for Cornish white is nominal at £50 per ton delivered.

BISMUTH.—The price has had a sharp drop to 7s. 6d. per lb. Business is quiet.

CADMIUM.—The current price is about 6s. 3d. per lb.

ALUMINIUM.—The price has been reduced to £150 per ton for home and export.

NICKEL.—The price has been reduced to £200 per ton for home and export.

COBALT METAL.—The price has been reduced to 20s. per lb

COBALT OXIDE.—Black oxide stands at 16s. and grey at 17s. 6d. per lb.

PLATINUM AND PALLADIUM.—These metals can be had at around £17 per oz., although more is asked for small quantities or in manufactured form.

QUICKSILVER.—The market has continued quiet, but in the absence of selling pressure values have been steady at about £12. 10s. to £12. 15s. per bottle.

SELENIUM.—The price stands at 10s. 6d. to 13s. per lb.

TELLURIUM.—The quotation continues at 90s. to 95s. per lb.

SULPHATE OF COPPER.—Business is quiet, and prices are easier at about £34 to £36 per ton.

MANGANESE ORE.—Values are lower at about 1s. 9d. to 1s. 10d. per unit c.i.f. U.K. for Indian grades.

TUNGSTEN ORES.—The current quotation for wolfram is about 14s. per unit c.i.f.

MOLYBDENITE.—85% stands at 57s. 6d. to 65s. per unit c.i.f. U.K.

CHROME ORES.—48% is quoted at about £5 c.i.f. U.K.

SILVER.—On February 1, the price of spot standard bars was 34½d. per oz., values improving to 37⅞d. on the 3rd. Subsequently 31⅜d. was touched, the price at the end of the month being 33d.

GRAPHITE.—Soft velvety flake 85 to 90% is quoted at £60 to £80 per ton. Madagascar 80 to 90% is quoted at £20 to £25 per ton.

IRON AND STEEL.—The past month has again been far from satisfactory to the British iron and steel trades. Pig iron makers have found their product almost unsaleable owing to the hesitation on the part of buyers to place orders here owing to slack trade and the lower prices quoted by the Continent. Prices have in consequence been reduced, No. 3 Cleveland G.M.B. standing at £7. 10s. for the home trade and £7. 15s. for export. Makers are being forced to curtail their output, and already sixteen Cleveland blast-furnaces have been blown out. In the finished branches of the trade many works are closed, or partly closed, owing to the lack of orders, and trade is gradually being brought to a standstill. Drastic reductions in prices have made their appearance, being desperate efforts to keep plants going, but orders are few and far between. The competition from the Continent is exceedingly keen, not only with this country, but there is also much scrambling among the Continental producers themselves to secure any business that is going, with the result that prices are ruthlessly cut.

STATISTICS.

PRODUCTION OF GOLD IN THE TRANSVAAL

	Rand	Elsewhere	Total	Price of gold per oz.
	Oz.	Oz.	Oz.	s. d.
Year 1919	[illegible]	[illegible]	8,330,091	
January, 1920	653,295	[illegible]	670,503	[illegible]
February	[illegible]	17,412	625,330	110 0
March	[illegible]	17 391	707,036	105 0
April	[illegible]	19,053	686,979	102 [illegible]
May	[illegible]	17,490	699,041	105 0
June	[illegible]	16,758	715,957	102 6
July	[illegible]	17,578	736,099	105 [illegible]
August	[illegible]	18,479	702,083	11[illegible] [illegible]
September	[illegible]	16,687	682,173	115 0
October	[illegible]	16,653	662,472	117 [illegible]
November	[illegible]	15,212	633,737	[illegible]
December	[illegible]	14,666	632,215	[illegible]
Total 1920	[illegible]	204,587	8,153,625	
January, 1921	[illegible]	[illegible]	[illegible]	105 [illegible]

NATIVES EMPLOYED IN THE TRANSVAAL MINES

	Gold mines	Coal mines	Diamond mines	Total
January 31, 1920	176,390	12,766	4,796	193,952
February 29	185,185	12,708	5,217	203,110
March 31	188,564	12,788	5,232	206 584
April 30	189,446	12,951	5,057	207,454
May 31	184,722	12,897	4,793	202,412
June 30	[illegible]	13,036	4,596	197,459
July 31	174,187	13,005	4,521	191,713
August 31	169,263	13,535	4,244	187,042
September 30	163,132	13,716	4,323	181,171
October 31	[illegible]	13 858	4,214	177,498
November 30	158,773	14,245	3,504	176,522
December 31	159,671	14,263	[illegible]	177,274
January 31, 1921	165,287	14,541	3,319	183,147

COST AND PROFIT ON THE RAND

Compiled from official statistics published by the Transvaal Chamber of Mines. The profit available for dividends is about 65% of the working profit. Figures for yield and profit for 1919 based on par value of gold; subsequently gold premium included.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
Year 1919	24,043,638	[illegible] 7	22 11	5 6	6,605,509
January, 1920	2,038,092	34 [illegible]	24 2	10 2	1,036,859
February	1,869,1[illegible]	3[illegible] 1	28 3*	6 10*	644,571*
March	2,188,104	31 [illegible]	25 2	6 6	716,610
April	2,065,446	31 [illegible]	26 [illegible]	5 2	533,940
May	2,117,725	31 9	25 11	5 10	618,147
June	2,146,890	31 10	25 2	6 8	692,510
July	2,194,050	33 6	24 6	9 0	985,058
August	2,057,560	36 11	25 0	11 11	1,226,906
September	1,950,410	38 11	25 6	13 5	1,276,369
October	1,871,140	39 9	26 1	13 8	1,278,385
November	1,799,710	[illegible]	[illegible] 3	13 1	1,255,749
December	1,797,970	39 11	26 8	13 3	1,193,672

* Results affected by the back-pay disbursed in accordance with new wages agreement.

PRODUCTION OF GOLD IN RHODESIA.

	1919	1920	1921
	£	oz.	oz.
January	211,917	43,428	46 956
February	220,885	44,237	—
March	225,808	45,779	—
April	213,160	47,000	—
May	218,057	46,266	
June	214,215	[illegible]	—
July	214 919	46,208	
August	207,339	48,740	
September	223,719	45,471	
October	204,184	47,343	—
November	186,462	46,782	
December	158,835	46,190	
Total	2,499,498	[illegible]	46,956

TRANSVAAL GOLD OUTPUTS

	January Treated	January Yield	February Treated	February Yield
	Tons	Oz.	Tons	Oz.
Aurora West	9,100	£13,064*	7,080	£10,030†
Brakpan	54,000	[illegible]	48,500	19,937
City Deep	83,500	35,867	52 500	[illegible]
Cons. Langlaagte	38,000	£61,172*	[illegible]	[illegible]
Cons. Main Reef	47,000	16,243	33,000	11,515
Crown Mines	185,000	[illegible]	124,000	42,328
Durban Roodepoort Deep	26,450	8,714	24,550	7,719
East Rand P. M.	116,000	[illegible]	112,000	29,099
Ferreira Deep	52,500	10,112	22,500	7,457
Geduld	45,000	15,644	40,000	14,058
Geldenhuis Deep	44,300	12,635	39,760	10,804
Glynn's Lydenburg	3,184	£6,203*	5,560	£5,560‡
Goch	16,100	£19,390*	12,000	£13,898†
Government G.M. Areas	132,500	£280,930*	[illegible]	£231,400†
Kleinfontein	47 060	12,868	43,800	11,723
Knight Central	23 000	6,013	21,300	5,469
Knights Deep				
Langlaagte Estate	38,300	£62,492*	27,100	£45,283†
Luipaard's Vlei	14,775	£17,683*	*	*
Meyer & Charlton	13,700	£43,1[illegible]	9,700	£31,540†
Modderfontein	91,000	43,560	85,000	39,580
Modderfontein B	55,000	26,540	50,000	25,324
Modderfontein Deep	42,600	22,864	39,400	21,656
Modderfontein East	25,700	10,572	25,000	[illegible]
New Unified	11,300	£13,239	9,300	£10,762†
Nourse	42,700	13,550	35,600	11,678
Primrose	19,500	£21,879*	20,300	£22,328†
Princess Estate	—		—	
Randfontein Central	117,000	£176,773*	100,500	£162,605†
Robinson	38,000	[illegible]	26,700	5,769
Robinson Deep	50,100	14,435	39,200	12,208
Roodepoort United	22,800	£22,956*	22,000	£22,224†
Rose Deep	53,800	12,414	47,500	10,748
Simmer & Jack	61,500	13,193	53,200	12,657
Springs	39,700	16,989	29,500	12,843
Sub Nigel	9,700	5,265	9,500	5,066
Transvaal G.M. Estates	16,650	£25,746*	14,835	£26,1[illegible]‡
Van Ryn	30,750	£48,763*	28,100	£44,519†
Van Ryn Deep	49,800	£137,046*	46,800	£127,877†
Village Deep	47,700	14,567	43,300	13,475
Village Main Reef		—	—	
West Rand Consolidated	33,400	£50,444*	30,100	£45,789†
Witwatersrand (Knights)	31,700	£46,352*	28,500	£43,041†
Witwatersrand Deep	32,400	£46,076*		**
Wolhuter	32,500	7,617	23,600	5,928

* £5. 5s. 0d. per oz. † £5. 3s. 9d. per oz. ‡ £5. 2s. 9d. per oz.
Returns not yet to hand.

WEST AFRICAN GOLD OUTPUTS

	December Treated	December Value	January Treated	January Value
	Tons	Oz.	Tons	Oz.
Abbontiakoon	5,029	£11,175*	6,330	£9,304*
Abosso	5,440	2,178	5,000	1,989
Akoko	206	156		—
Ashanti Goldfields	5,110	3,251	4,691	5,375
Obbuassi	670	£[illegible],556†	680	£2 252†
Prestea Block A	8,545	£16,523*	7,898	£14,534*
Taquah	2,720	1,500	2,755	1,520

* At par. † Including premium.

RHODESIAN GOLD OUTPUTS.

	December Treated	December Oz.	January Treated	January Oz.
	Tons		Tons	
Falcon	15,130	2,991	15,301	2,803*
Gaika	3,558	1,175	2,813	1,383
Globe & Phœnix	5,560	7,611	5,949	7,206
London & Rhodesian	3,844	£2,467†		
Lonely Reef	5,280	5,115	5,350	5,219
Planet-Arcturus	5,900	2,713	5,7[illegible]0	2,535
Rezende	5,700	2,513	5,436	2,536
Rhodesia, Ltd.		—		
Rhodesia G.M. & I.	660	228	661	253
Shamva	50,300	£41,312‡	50,700	£40,450§
Transvaal & Rhodesian	1,300	£[illegible]	1,550	£5,440†

* Also 241 tons copper. § Gold at 110s. per oz. ‖ Also 2[illegible]5 tons copper. ‡ Gold at 105s. per oz. † At par.

West Australian Gold Statistics.—Par Values

	Reported for Export oz.	Delivered to Mint oz.	Total oz.	Total value £
January, 1920	836	25,670	26,506	112,590
February	1,928	49,453	51,381	218,251
March	—	54,020	54,020	229,461
April	835	56,256	57,091	242,506
May	227	50,976	51,203	217,495
June	502	56,679	57,181	242,638
July	—	48,341	48,341	205,340
August	167	54,258	54,425	231,185
September	141	54,940	55,081	233,963
October	174	53,801	53,975	229,275
November	128	54,729	54,857	233,017
December	321	53,595	53,916	229,057
January, 1921	523	50,934	51,457	218,574
February	684	26,872	27,556	117,050

Australian Gold Returns.

	Victoria.		Queensland.		New South Wales	
	1919	1920	1919	1920	1920	1921
	£	Oz.	£	Oz.	£	£
January	36,238	7,105	37,100	4,724	28,000	20,463
February	46,955	8,677	43,330	7,200	15,000	—
March	40,267	24,126	48,000	6,973	22,000	—
April	63,818	6,368	61,200	8,368	12,000	
May	37,456	13,263	38,200	8,432	13,800	
June	41,465	15,707	44,600	13,725	8,700	
July	37,395	12,782	42,060	9,596	17,410	—
August	51,564	12,809	49,700	9,973	17,168	—
September	76,340	13,973	37,120	11,789	13,872	
October	39,018	13,432	36,100	9,300	24,752	
November	40,735	9,245	32,720	10,200	16,907	—
December	63,311	15,305	44,500	12,874	18,137	—
Total	575,260	152,792	514,630	114,181	207,746	20,463

Australasian Gold Outputs.

	December		January.	
	Treated	Value	Treated	Value
	Tons	£	Tons	£
Associated G.M. (W.A.)	5,069	6,050	2,677	2,907
Blackwater (N.Z.)	2,700	5,822	2,129	3,471‖
Bullfinch (W.A.)	5,500	5,738	5,350	5,528
Golden Horseshoe (W.A.)	5,064	1,945‡	3,528	1,772‡
Great Boulder Pro. (W.A.)	4,479	18,251	3,544	10,623‖
Ivanhoe (W.A.)	6,960	2,760‡	4,987	2,193‡
Kalgurli (W.A.)	2,707	4,642‖	—	-
Lake View & Star (W.A.)	5,330	11,995†	—	—
Menzies Con. (W.A.)	1,160	2,132	1,360	2,289
Mount Boppy (N.S.W.)	5,385	2,283‡	5,672	1,760‡
Oroya Links (W.A.)	1,461	10,649†		-
Progress (N.Z.)	—	—		—
Sons of Gwalia (W.A.)	12,917	15,806	—	—
South Kalgurli (W.A.)	4,308	9,645†	—	—
Waihi (N.Z.)	11,393	4,192‡ 23,993§	7,087	1,787 23,654
Waihi Grand Junc'n (N.Z.)	5,630	2,384‡ 11,153§		— —
Yuanmi (W.A.)	1,460	5,029*	1,320	4,123*

† Including royalties; ‡ Oz gold; § Oz silver. At par.
* Including premium.

Miscellaneous Gold and Silver Outputs.

	December		January.	
	Treated	Value	Treated	Value
	Tons	£	Tons	£
Brit. Plat. & Gold (C'lbia)	—	66§		221§
El Oro (Mexico)	31,500	210,000†	29,500	200,000†
Esperanza (Mexico)	—	3,241‡†	—	1,249‡†
Frontino & Bolivia (C'lbia)	2,670	7,833	2,020	5,558
Mexico El Oro (Mexico)	12,200	164,410†	12,050	163,240†
Mining Corp. of Canada	—	196,033*	—	—
Oriental Cons. (Korea)	15,931	106,211†	—	*75,500†
Ouro Preto (Brazil)	6,200	2,11[illegible]	6,300	2,08[illegible]
Plymouth Cons. (Calif'rnia)	8,350	10,832	9,000	11,435
St. John del Rey (Brazil)	—	34,000	-	35,000
Santa Gertrudis (Mexico)	37,588	16,827‡	37,588	10,104‡
Sonora (Mexico)	—	—	—	—
Tolima (Colombia)	55**	—	75	-
Tomboy (Colorado)	15,000	79,000†	15,000	71,000†

† U.S. Dollars. ‡ Profit, gold and silver. ‖ Oz. gold. * Oz. silver.
§ Oz. platinum and gold. ** Production of silver ore.

Production of Gold in India.

	1917	1918	1919	1920	1921
	oz.	oz.	oz.	oz.	oz.
January	44,718	41,420	38,184	39,073	34,028
February	42,566	40,787	36,834	38,872	32,529
March	44,617	41,719	38,317	38,760	—
April	43,726	41,504	38,248	37,307	—
May	42,901	40,889	38,608	38,191	—
June	42,924	41,264	38,359	37,864	—
July	42,273	40,229	38,549	37,129	
August	42,591	40,496	37,850	37,375	
September	43,207	40,088	36,813	35,497	—
October	43,041	39,472	37,138	35,023	-
November	42,915	36,984	39,628	34,522	
December	44,883	40,149	42,643	34,919	—
Total	520,362	485,236	461,171	444,532	66,557

Indian Gold Outputs.

	January.		February.	
	Tons Treated	Fine Ounces	Tons Treated	Fine Ounces
Balaghat	3,200	2,323	3,000	2,220
Champion Reef	11,293	5,512	10,831	4,561
Mysore	16,515	11,798	15,950	11,563
North Anantapur	700	920	700	917
Nundydroog	8,553	5,021	8,324	4,901
Ooregum	12,900	8,464	12,500	8,367

Base Metal Outputs.

		Dec.	Jan.
Arizona Copper	Short tons copper	1,325	1,150
British Broken Hill	Tons lead conc.	2,330	1,320
	Tons zinc conc.	2,120	1,190
	Tons carbonate ore.	580	40
Broken Hill Prop.	Tons lead conc.	533	845
	Tons zinc conc.	1,207	2,460
Broken Hill South	Tons lead conc.	—	1,693
Burma Corp.	Tons refined lead	2,445	2,548
	Oz. refined silver	280,210	234,487
Fremantle Trading	Long tons lead	352	473
Hampden Cloncurry	Tons copper	282	—
	Oz. gold	141	—
Kafue Copper	Short tons copper	—	—
Mount Lyell	Tons copper	357	672*
	Oz. silver	12,279	24,277*
	Oz. gold	352	726
Mount Morgan	Tons copper	587	340
	Oz. gold	9,517	4,485
North Broken Hill	Tons lead	—	—
	Oz. silver	—	—
Pilbara Copper	Tons ore	132	170
Poderosa	Tons copper ore	200	150
Rhodesian Broken Hill	Tons lead	1,323	1,442
S'th American Copper	Tons cop. ore ship'd.	—	—
Sulphide Corporation	Tons lead conc.	1,373	1,585
	Tons zinc. conc.	1,979	2,580
Tanganyika	Long tons copper	—	—
Zinc Corp.	Tons zinc conc.	—	4,015
	Tons lead conc.	—	287

* For period December 16 to February 9.

Imports of Ores, Metals, etc., into United Kingdom.

		Jan., 1921.	Feb., 1921.
Iron Ore	Tons	569,515	283,839
Manganese Ore	Tons	48,312	35,193
Copper and Iron Pyrites	Tons	61,924	40,719
Copper Ore, Matte, and Precipitate	Tons	843	3,555
Copper Metal	Tons	7,508	7,186
Tin Concentrate	Tons	1,379	2,546
Tin Metal	Tons	2,662	1,581
Lead, Pig and Sheet	Tons	12,113	14,684
Zinc (Spelter)	Tons	7,945	4,319
Quicksilver	Lb.	2,277	16,982
Zinc Oxide	Tons	389	239
White Lead	Cwt.	12,602	5,939
Barytes, ground	Cwt.	31,738	22,646
Phosphate	Tons	92,705	37,465
Sulphur	Tons	—	—
Borax	Cwt.	600	960
Other Boron Compounds	Tons	1,306	1,428
Nitrate of Soda	Cwt.	138,880	133,664
Nitrate of Potash	Cwt.	744	7,525
Petroleum:			
Crude	Gallons	—	920,111
Lamp Oils	Gallons	19,387,468	14,621,854
Motor Spirit	Gallons	32,124,702	13,775,416
Lubricating Oils	Gallons	10,888,366	3,392,702
Gas Oil	Gallons	4,690,163	3,193,753
Fuel Oil	Gallons	28,691,484	33,515,259
Total Petroleum	Gallons	95,782,423	69,420,821

Outputs of Tin Mining Companies
In Tons of Concentrate.

	Nov. Tons	Dec. Tons	Jan. Tons
Nigeria			
Associated Nigerian	[illegible]	20	7
Benue			
Bisichi	16	10	5
Bongwelli	1¼	[illegible]	5
Champion (Nigeria)		[illegible]	
Dua	[illegible]	1½	[illegible]
Ex Lands	35	[illegible]	30
Filani	5	[illegible]	[illegible]
Forum River	[illegible]	10½	–
Gold Coast Consolidated	½	[illegible]	
Gurum River	15	12	11
Jantar	10	20	
Jos	1¼	76[illegible]	
Kaduna	17½	15½	14
Kaduna Prospectors	9	8¼	6
Kano	5¼		[illegible]
Kuru			
Kwall			–
Lower Bisichi	8½	7¾	9¼
Lucky Chance	1	1	–
Minna	–	1[illegible]	1
Mongu	40	50	51
Naraguta	45	42	35
Naraguta Extended	15	17	10
Nigerian Consolidated	[illegible]	23	17
Ninghi	5¼	5	
N.N. Bauchi	5[illegible]	50	40
Ofin River	7¼	9¼	
Rayfield	[illegible]5	37	4
Ropp	115	126	86
Rukuba	4	4½	4
South Bukeru	15	15	18
Sybu		4½	1
Tin Fields	4	1	4
Yarde Kerri	4	5	[illegible]
Federated Malay States:			
Chenderiang	–	103*	
Gopeng	72	66	72
Idris Hydraulic	19¼	17¾	
Ipoh	13	19½	19¼
Kamunting	–	120*	
Kinta	[illegible]2¾	35¼	31¼
Lahat	59½	60¼	68¼
Malayan Tin	78¾	83¼	80½
Pahang	166	166	166
Rambutan	16½	15	16½
Sungei Besi	31	30	33
Tekka	30	30	25½
Tekka Taiping	31	27	21
Tronoh	[illegible]	29	36
Cornwall			
East Pool	74†	89¾†	95†
Geevor		–	—
Grenville			—
South Crofty	60¼†	62†	55†
Other Countries:			
Aramayo Francke (Bolivia)	170	154	157
Berenguela (Bolivia)	27	18	24
Briseis (Tasmania)	23	13	11
Deebook (Siam)	19½	30½	20
Leeuwpoort (Transvaal)	—	247*	
Mactready (Swaziland)	–	19*	—
Mawchi (Burma)			
Porco (Bolivia)	—		
Renong (Siam)	[illegible]	89¼	90
Rooiberg Minerals (Transvaal)	15	–	45
Siamese Tin (Siam)	63¼	71¾	83
Tongkah Harbour (Siam)	76	73	67
Zaaiplaats (Transvaal)	28	27	21

* Three months. † Tin and wolfram

Nigerian Tin Production
In long tons of concentrate of unspecified content

Note. These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual outputs

	1916	1917	1918	1919	1920	1921
	Tons	Tons	Tons	Tons	Tons	Tons
January	531	667	678	613	547	438
February	528	646	668	623	477	
March	547	655	707	606	505	
April	486	555	584	546	467	
May	536	509	525	483	383	—
June	510	473	492	484	435	—
July	506	479	545	481	484	—
August	498	551	571	616	447	—
September	535	538	520	561	548	—
October	584	578	491	625	628	—
November	679	621	472	536	544	—
December	654	655	518	511	577	—
Total	6,594	6,927	6,771	6,685	6,022	438

Production of Tin in Federated Malay States.
Estimated at 70% of Concentrate shipped to Smelters.
Long Tons.

	1917	1918	1919	1920	1921
	Tons	Tons	Tons	Tons	Tons
January	3,558	3,030	3,765	4,265	3,298
February	2,755	3,197	2,734	3,014	—
March	3,286	2,609	2,819	2,770	—
April	3,251	3,308	2,858	2,606	
May	3,413	3,332	3,407	2,741	
June	3,489	3,070	2,877	2,940	
July	3,253	3,373	3,756	2,824	
August	3,413	3,259	2,956	2,786	
September	3,154	3,157	3,161	2,734	
October	3,436	2,870	3,221	2,837	
November	3,300	3,132	2,972	2,573	
December	3,525	3,022	2,409	2,838	-
	39,833	37,370	36,935	34,928	3,298

Total Sales of Tin Concentrate at Redruth Ticketings

	Long tons	Value	Average
August 25, 1919	130½	£18,297	£140 4 3
September 8	115½	£16,588	£143 12 6
September 22	135½	£19,557	£144 6 9
October 8	72	£10,867	£150 18 7
October 20	32	£5,093	£159 3 2
November 3	34½	£5,235	£151 15 0
November 17	39	£6,161	£157 19 9
December 1	38	£5,905	£155 8 3
December 15	29	£5,133	£176 10 0
December 31	14¾	£2,884	£195 10 10
Total and Average, 1919	2,858	£366,569	£128 5 0
January 12, 1920	31	£6,243	£201 8 0
January 26	51¾	£10,574	£204 6 10
February 9	37½	£7,880	£210 2 8
February 23	53¾	£12,120	£225 10 0
March 8	18	£4,038	£224 7 7
March 22	44	£8,286	£188 6 8
April 6	44½	£8,367	£188 0 5
April 19	33½	£6,375	£190 6 0
May 3	61½	£11,641	£189 5 9
May 17	44	£6,151	£139 16 0
May 31	10	£1,578	£157 16 0
June 14	24¾	£3,278	£132 9 3
June 28	14½	£1,932	£133 4 10
July 12	43¾	£6,133	£140 4 0
July 26	10½	£1,643	£156 10 0
August 9	10½	£1,664	£158 10 0
August 23	27¼	£4,022	£147 12 0
September 6	19	£2,563	£134 18 6
September 20	10	£1,552	£155 5 0
October 4	9	£1,359	£151 0 7
October 18	39½	£5,225	£132 5 11
November 1	9	£1,329	£147 14 5
November 15	4½	£597	£132 17 6
November 29	[illegible]	£965	£113 12 0
December 13	8½	£981	£115 8 6
December 28	8½	£946	£111 5 10
January 10, 1921	8½	£991	£116 13 0
January 24	7½	£671	£89 11 4

☛ Ticketings suspended.

Stocks of Tin.

Reported by A. Strauss & Co. Long Tons.

	Dec 31	Jan 31	Feb. 28
Straits and Australian Spot	2,170	2,701	2,128
Ditto, Landing and in Transit	1,138	40	10
Other Standard, Spot and Landing	3,855	4,960	5 365
Straits, Afloat	1,183	345	40
Australian, Afloat	250	264	295
Banca, in Holland	3,511	3,341	3,187
Ditto, Afloat	278	356	209
Billiton, Spot	755	755	755
Billiton, Afloat	264	141	—
Straits, Spot in Holland and Hamburg	—	—	
Ditto, Afloat to Continent	485	60	
Total Afloat for United States	1,734	2,595	1,385
Stock in America	2,856	2,546	3,546
Total	18,479	18,104	16,900

Shipments, Imports, Supply, and Consumption of Tin

Reported by A. Strauss & Co. Long tons.

	Dec.	Jan.	Feb.
Shipments from:			
Straits to U.K.	915	35	20
Straits to America	825	960	220
Straits to Continent	485	60	
Straits to Other Places	225	106	33
Australia to U.K.	250	350	100
U.K. to America	150	955	715
Imports of Bolivian Tin into Europe	251	341	800
Supply:			
Straits	2,225	1,055	240
Australian	250	350	100
Billiton		–	
Banca	250	498	-
Standard	1,500	1,290	1,561
Total	4,225	3,193	1,961
Consumption:			
U K. Deliveries	1,518	1,254	1,321
Dutch ,,	366	269	164
American ,,	2,580	1,555	1,585
Straits, Banca & Billiton, Continental Ports, etc.	347	490	35
Total	4,811	3,568	3,568

Dividends Declared by Mining Companies.

Date	Company	Par Value of Shares	Amount of Dividend
March 8	Borax Consolidated	Def Ord. £1.	2s. less tax
March 9	Broken Hill Block 14	Pref. 6s.	5%
Feb. 16	Consolidated Mines Selection	10s.	15% less tax
Feb. 10	Exploration Co.	10s.	10% tax paid
March 4	Ginsberg	£1.	5s.*
March 4	Glencairn	£1.	2s.*
March 9	Great Boulder	2s.	6d. less tax
March 9	Mexico of El Oro	£1.	4s. tax paid
Feb. 24	Mysore Gold	10s.	1s. 9d. less tax
March 3	Nechi Mines	Ord. 10s.	5s. less tax
March 10.	New Gold Trust	£1.	1s. tax paid
Feb. 24	North Anantapur Gold Mines	Pref. £1.	20% less tax
March 3	Oroville Dredging	£1.	9d. less tax
Feb. 14	Rambutan	£1.	8d. less tax
March 4	South African Gold Trust	£1.	1s. 3d. tax paid
Feb. 15	Vereeniging Estates	£1	5% less tax
March 1	Village Main Reef	£1.	6s. 8d.*
Feb. 18	Witbank Colliery	£1.	17½% less tax
Feb. 22	Witwatersrand Deep	£1.	5% less tax

* First distribution of assets on liquidation.

PRICES OF CHEMICALS. March 8.

These quotations are not absolute; they vary according to quantities required and contracts running.

		£	s.	d.
Acetic Acid, 40%	per cwt	1	5	0
,, 80%	,,	2	10	0
,, Glacial	,,	3	6	0
Alum	per ton	19	0	0
Alumina, Sulphate of	,,	16	0	0
Ammonia, Anhydrous	per lb.		2	6
,, 0 880 solution	per ton	46	0	0
,, Carbonate	per lb.			4
,, Chloride of, grey	per ton	54	0	0
,, ,, ,, pure	per cwt.	5	0	0
,, Nitrate of	per ton	50	0	0
,, Phosphate of	,,	95	0	0
,, Sulphate of	,,	24	0	0
Antimony, Tartar Emetic	per lb.		2	7
,, Sulphide, Golden	,,		1	6
Arsenic, White	per ton	50	0	0
Barium Carbonate	,,	11	0	0
,, Chlorate	per lb.		1	0
,, Chloride	per ton	20	0	0
,, Sulphate	,,	10	0	0
Benzol, 90%	per gal.		3	0
Bisulphate of Carbon	per ton	55	0	0
Bleaching Powder, 35% Cl.	,,	19	0	0
,, Liquor, 7%	,,	7	0	0
Borax	,,	38	0	0
Boric Acid, crystals	,,	74	0	0
Calcium Chloride	,,	10	0	0
Carbolic Acid, crude 60%	per gal.		1	10
,, crystallized, 40%	per lb.			8
China Clay (at Runcorn)	per ton	3 10 0 to 4 10 0		
Citric Acid	per lb.		2	3
Copper, Sulphate of	per ton	35	0	0
Cyanide of Sodium, 100%	per lb.		1	0
Hydrofluoric Acid	,,			7½
Iodine	per oz.		1	0
Iron, Nitrate of	per ton	10	0	0
,, Sulphate of	,,	4	0	0
Lead, Acetate of, white	,,	50	0	0
,, Nitrate of	,,	50	0	0
,, Oxide of, Litharge	,,	40	0	0
,, White	,,	46	0	0
Lime, Acetate, brown	,,	12	0	0
,, ,, grey 80%	,,	19	0	0
Magnesite, Calcined	,,	21	0	0
Magnesium, Chloride	,,	12	0	0
,, Sulphate	,,	10	0	0
Methylated Spirit 64° Industrial	per gal.		7	0
Nitric Acid, 80° Tw.	per ton	37	0	0
Oxalic Acid	per lb.		10	0
Phosphoric Acid	per lb.		1	6
Potassium Bichromate	per lb.		1	1
,, Carbonate 85%	per ton	45	0	0
,, Chlorate	per lb.		0	6
,, Chloride 80%	per ton	24	0	0
,, Hydrate (Caustic) 90%	,,	48	0	0
,, Nitrate	,,	48	0	0
,, Permanganate	per lb.		2	0
,, Prussiate, Yellow	,,		1	4
,, ,, Red	,,		2	0
,, Sulphate, 90%	per ton	25	0	0
Sodium Metal	per lb.		1	3
,, Acetate	per ton	33	0	0
,, Arsenate 45%	,,	45	0	0
,, Bicarbonate	,,	9	0	0
,, Bichromate	per lb.			10
,, Carbonate (Soda Ash)	per ton	15	0	0
,, ,, (Crystals)	,,	7	0	0
,, Chlorate	per lb.			4½
,, Hydrate, 76%	per ton	27	0	0
,, Hyposulphite	,,	20	0	0
,, Nitrate, 95%	,,	22	0	0
,, Phosphate	,,	25	0	0
,, Prussiate	per lb.			8
,, Silicate	per ton	11	0	0
,, Sulphate (Salt-cake)	,,	9	0	0
,, ,, (Glauber's Salts)	,,	9	0	0
,, Sulphide	,,	30	0	0
,, Sulphite	,,	13	0	0
Sulphur, Roll	,,	15	0	0
,, Flowers	,,	15	0	0
Sulphuric Acid, Fuming, 65°	,,	24	0	0
,, ,, free from Arsenic, 144°	,,	6	5	0
Superphosphate of Lime, 30%	,,	8	10	0
Tartaric Acid	per lb.		2	0
Turpentine	per cwt.	3	3	0
Tin Crystals	per lb.		1	7
Titanous Chloride	,,		1	0
Zinc Chloride	per ton	27	0	0
Zinc Sulphate	,,	19	0	0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS	Mar. 5, 1920 £ s. d.	Mar. 7, 1921 £ s. d.
RAND:		
Brakpan	3 15 0	2 10 0
Central Mining (£8)	11 3 9	6 2 6
City & Suburban (£4)	8 0	6 9
City Deep	3 [illegible] 0	2 0 0
Consolidated Gold Fields	2 2 6	16 3
Consolidated Langlaagte	1 8 0	12 6
Consolidated Main Reef	15 6	10 3
Consolidated Mines Selection (10s.)	1 13 3	13 9
Crown Mines (10s.)	4 0 0	2 0 0
Daggafontein	1 0 6	2 6
Durban Roodepoort Deep	11 3	2 6
East Rand Proprietary	14 6	5 0
Ferreira Deep	13 0	9 0
Geduld	2 15 0	2 5 0
Geldenhuis Deep	15 0	6 0
Gov't Gold Mining Areas	4 17 6	3 15 0
Heriot	12 0	9 6
Johannesburg Consolidated	1 15 0	1 2 0
Jupiter	7 0	3 3
Kleinfontein	16 3	6 0
Knight Central	6 9	3 6
Knights Deep	12 6	12 6
Langlaagte Estate	1 0 0	10 6
Meyer & Charlton	4 17 6	4 2 6
Modderfontein (10s.)	4 3 9	3 5 0
Modderfontein B (5s.)	7 17 6	1 5 0
Modderfontein Deep (5s.)	2 13 9	2 0 0
Modderfontein East	1 8 9	17 6
New State Areas	1 10 0	1 2 6
Nourse	16 9	6 9
Rand Mines (5s.)	4 6 3	2 2 6
Rand Selection Corporation	5 2 6	2 5 0
Randfontein Central	1 2 0	8 6
Robinson (£5)	13 0	9 3
Robinson Deep A (1s.)	1 10 0	11 3
Rose Deep	1 3 9	12 6
Simmer & Jack	6 9	2 6
Simmer Deep	3 3	—
Springs	2 18 9	1 12 6
Sub Nigel	1 0 0	11 3
Union Corporation (12s. 6d.)	1 3 6	16 0
Van Ryn	1 2 6	11 3
Van Ryn Deep	5 0 0	3 2 6
Village Deep	17 3	7 0
Village Main Reef	9 0	12 9
West Springs	1 5 0	15 0
Witwatersrand (Knight's)	1 4 3	11 3
Witwatersrand Deep	14 0	6 9
Wolhuter	6 9	3 9
OTHER TRANSVAAL GOLD MINES:		
Glynn's Lydenburg	17 6	8 9
Transvaal Gold Mining Estates	16 9	8 3
DIAMONDS IN SOUTH AFRICA:		
De Beers Deferred (£2 10s.)	30 0 0	9 15 0
Jagersfontein	6 15 0	1 17 6
Premier Deferred (2s. 6d.)	12 5 0	4 5 0
RHODESIA:		
Cam & Motor	13 0	7 6
Chartered British South Africa	1 1 0	12 0
Falcon	14 9	6 6
Gaika	15 6	8 6
Globe & Phœnix (5s.)	14 0	18 6
Lonely Reef	3 6 3	1 17 6
Rezende	3 15 0	2 12 6
Shamva	2 3 9	1 7 6
Willoughby's (10s.)	6 9	5 3
WEST AFRICA:		
Abbontiakoon (10s.)	5 0	2 0
Abosso	14 0	8 0
Ashanti (4s.)	1 [illegible] 9	11 3
Prestea Block A	4 9	1 6
Taquah	1 0 0	7 6
WEST AUSTRALIA:		
Associated Gold Mines	7 6	2 6
Associated Northern Blocks	5 6	2 6
Bullfinch	9 0	6
Golden Horse Shoe (£5)	1 6 3	12 6
Great Boulder Proprietary (2s.)	8 9	5 6
Great Fingall (10s.)	2 6	1 6
Hampton Properties	1 18 9	6 3
Ivanhoe (£5)	2 7 6	18 9
Kalgurli	18 9	7 6
Lake View Investment (10s.)	19 0	9 9
Sons of Gwalia	10 0	5 0
South Kalgurli (10s.)	7 3	5 6

GOLD, SILVER, cont.	Mar. 5, 1920 £ s. d.	Mar. 7, 1921 £ s. d.
OTHERS IN AUSTRALASIA		
Blackwater, New Zealand	8 9	2 6
Consolidated G.F. of New Zealand	3 9	2 6
Mount Boppy, N.S.W. (10s.)	5 3	3 6
Progress, New Zealand	1 9	1 3
Talisman, New Zealand	8 9	6 6
Waihi, New Zealand	2 6 3	1 6 [illegible]
Waihi Grand Junction, New Zealand	11 5	7 6
AMERICA:		
Buena Tierra, Mexico	12 6	5 0
Camp Bird, Colorado	1 1 6	5 6
El Oro, Mexico	15 3	10 0
Esperanza, Mexico	17 0	16 3
Frontino & Bolivia, Colombia	11 9	8 9
Le Roi No. 2 (£5), British Columbia	10 0	5 0
Mexico Mines of El Oro, Mexico	8 5 0	4 8 9
Nechi (Pref. 10s.), Colombia	10 6	6 3
Oroville Dredging, Colombia	1 7 6	1 2 6
Plymouth Consolidated, California	1 1 3	17 6
St. John del Rey, Brazil	18 0	15 0
Santa Gertrudis, Mexico	1 15 3	7 3
Tomboy, Colorado	13 9	6 3
RUSSIA:		
Lena Goldfields	1 8 9	8 9
Orsk Priority	12 6	5 0
INDIA		
Balaghat (10s.)	9 9	7 6
Champion Reef (2s. 6d.)	4 3	2 3
Mysore (10s.)	1 0 0	12 6
North Anantapur	4 6	5 0
Nundydroog (10s.)	17 3	6 0
Ooregum (10s.)	18 0	12 6
COPPER:		
Arizona Copper (5s.), Arizona	3 6 3	1 3 9
Cape Copper (£2), Cape and India	2 0 0	15 0
Esperanza, Spain	5 9	5 0
Hampden Cloncurry, Queensland	18 0	5 0
Mason & Barry, Portugal	2 10 0	1 10 0
Messina (5s.), Transvaal	6 6	4 0
Mount Elliott (£5), Queensland	3 10 0	7 6
Mount Lyell, Tasmania	1 6 6	11 3
Mount Morgan, Queensland	1 6 0	11 3
Mount Oxide, Queensland	8 0	—
Namaqua (£2), Cape Province	1 12 6	17 6
Rio Tinto (£5), Spain	46 10 0	24 0 0
Russo-Asiatic Consd., Russia	14 3	7 9
Sissert, Russia	16 [illegible]	5 0
Spassky, Russia	1 7 6	19 0
Tanganyika, Congo and Rhodesia	2 16 3	1 2 6
LEAD-ZINC:		
BROKEN HILL		
Amalgamated Zinc	1 6 6	15 0
British Broken Hill	2 5 0	15 0
Broken Hill Proprietary	3 2 6	1 15 0
Broken Hill Block 10 (£10)	1 7 6	10 0
Broken Hill North	2 7 6	1 2 6
Broken Hill South	2 18 9	1 1 3
Sulphide Corporation (15s.)	1 0 6	11 3
Zinc Corporation (10s.)	1 1 6	7 6
ASIA:		
Burma Corporation (10 rupees)[1]	12 17 6	7 3
Russian Mining	15 0	5 0
RHODESIA:		
Rhodesia Broken Hill (5s.)	17 0	6 0
TIN:		
Aramayo Francke, Bolivia	5 5 0	1 15 0
Bisichi, Nigeria	16 0	6 3
Briseis, Tasmania	5 3	2 6
Dolcoath, Cornwall	8 6	6
East Pool (5s.) Cornwall	15 0	2 6
Ex-Lands Nigeria (2s.), Nigeria	4 6	2 0
Geevor (10s.) Cornwall	1 2 6	3 9
Gopeng, Malay	2 8 9	1 10 0
Ipoh Dredging, Malay	1 9 0	11 3
Kamunting, Malay	1 10 0	1 7 0
Kinta, Malay	3 1 3	1 10 0
Malayan Tin Dredging, Malay	2 13 9	1 2 6
Mongu (10s.), Nigeria	1 8 6	11 3
Naraguta, Nigeria	18 9	12 6
N. N. Bauchi, Nigeria (10s.)	9 0	1 9
Pahang Consolidated (5s.), Malay	15 3	6 0
Rayfield, Nigeria	14 6	3 6
Renong Dredging, Siam	2 13 9	1 5 0
Ropp (4s.), Nigeria	16 9	5 0
Siamese Tin, Siam	4 10 0	2 5 0
South Crofty (5s.), Cornwall	17 9	4 0
Tehidy Minerals, Cornwall	1 7 6	10 0
Tekka, Malay	5 5 0	17 6
Tekka-Taiping, Malay	1 11 3	1 1 3
Tronoh, Malay	2 15 0	1 5 0

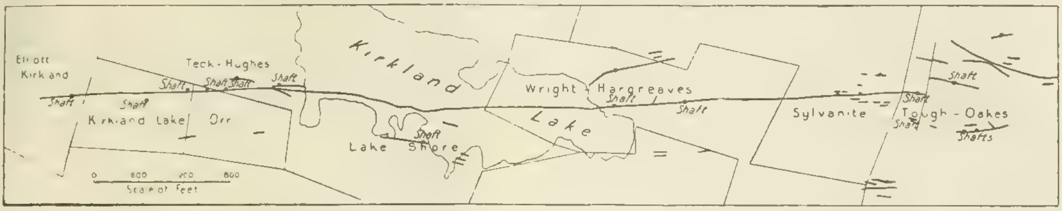
[1] 10-rupee shares of Indian Co.

THE MINING DIGEST

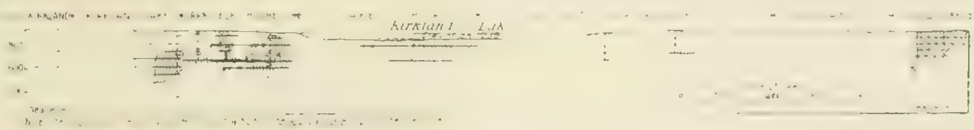
A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also notices of new books and pamphlets, lists of patents on mining and metallurgical subjects, and abstracts of the yearly reports of mining companies.

THE KIRKLAND LAKE GOLD MINING DISTRICT.



PLAN SHOWING PRINCIPAL WORKINGS AND LODES AT KIRKLAND LAKE.

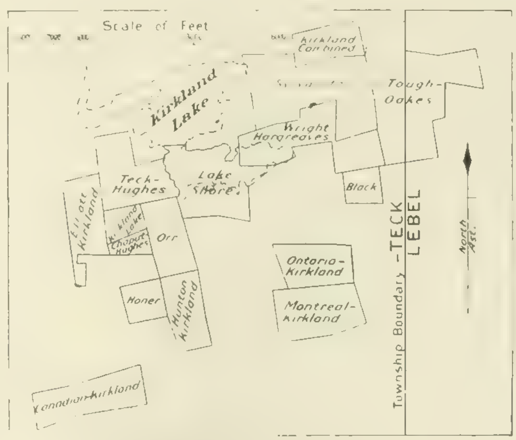


SECTION OF PRINCIPAL WORKINGS ALONG THE LINE OF LODE.

Last month we quoted the report by A. G. Burrows and P. E. Hopkins on the Kirkland Lake district, made for the Ontario Department of Mines, reproducing that part of the report dealing with the general geology and the ore deposits. Herewith we give their account of the development work done at each mine.

Elliott Kirkland.—This property lies to the west of the Kirkland Lake mine. It includes three claims, on the principal of which the shaft and mine buildings are located. The main fracture zone has been traced westerly through low land from the Kirkland Lake mine. A vertical shaft has been sunk 537 ft., with cross-cuts on five levels and drifts on the third, fourth, and fifth levels along fault planes. The rocks encountered are porphyry, lamprophyre, syenite, and reddish felspathic quartzite. During the time of the strike at Kirkland Lake the workings were allowed to fill with water and no further exploratory work has since been done.

Kirkland Lake.—The Kirkland Lake Gold Mining Company is operating the claim formerly known as the McKane, situated one-quarter of a mile south-west of the lake. Native gold had been discovered in the main vein by the early operators, who also sank No. 1 shaft to a moderate depth. The original discovery was made through about 20 ft. of overburden, the strike of the vein having been determined from workings on the Teck-Hughes and other properties. There are two vertical shafts on the property. No. 1 is in the north-east part of the claim near the Orr line and has been sunk to a depth of 700 ft. (April 1, 1920). The mineralization was followed to 104 ft., where the vein left the shaft on the south side. From the different levels cross-cuts were run to the south to intersect the vein. Since the vein dips approximately 85° S., the cross-cuts are slightly longer at each succeeding level. Drifts have been run on seven levels, but those on the first and second are short, the values obtained not having been as good as those from the 300 ft. to the 700 ft.



PLAN OF MINING PROPERTIES AT KIRKLAND LAKE.

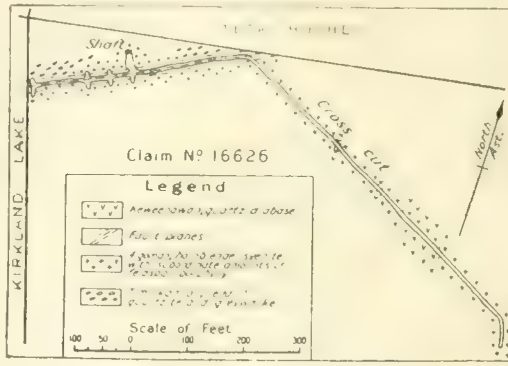
levels. A main hoisting shaft is 600 ft. south-west from No. 1 shaft and to the south of the main vein as exposed on the surface. This contains two hoisting compartments and a manway compartment, and is connected on the third, fourth, and fifth levels with the main workings along No. 1 vein. With depth the connecting cross-cuts become shorter owing to the dip of the vein to the south.

The main vein is recognized by the presence of fault planes, which dip to the south. These are called the foot-wall and hanging-wall planes, and they vary considerably in distance apart in different sections of the mine. At the cross-cuts from No. 1 shaft on the 400 ft., 500 ft., 600 ft., and 700 ft. levels they are respectively 19 ft., 33 ft., 40 ft., and 40 ft. apart. The area between the principal faults is very much disturbed, since minor

fault planes and cross slips have in part controlled the ore deposition. Exploration has shown that there is consequently great irregularity in the mineralization in the fractured zone and values change quite rapidly in driving along the vein. The development has been carried on with regard to the two principal planes or vein boundaries. On the 400 ft. and 500 ft. levels drifts have been run on the foot-wall and hanging-wall sides of the vein for some distance, and up to the present time the greatest amount of development has been done on these levels, where large stopes have been opened up, that on the 400 ft. level being about 300 ft in length and 23 ft. wide at one point. The assay-plans of the stopes have shown the greatest values to be in the foot-wall section of the vein. Development has also shown that the ore sometimes extends beyond the recognized vein boundary planes. The best grade of ore has been obtained where the fault planes or vein boundaries are moderate distances apart, roughly 15 ft to 25 ft. Where they are within a few feet of each other the values are not so good, and where very widely apart the values have a tendency to become more scattered. The ground between the fault planes is so broken and contains so many slip planes that it has been found advisable to leave solid backs above the drifts to protect them from the weight of broken ore in the stopes.

The development has so far indicated that the principal ore shoot extends from above the 300 ft. level to below the 700 ft. level, the deepest workings up to this time The ore-shoot pitches somewhat to the west, but sufficient development has not been accomplished to delimit its actual outline. On the third, fourth, and fifth levels the ore-shoot extends easterly to the Orr west boundary Some gold values are generally obtained along the main vein fracture, but these are not always of commercial importance. However, this mineralization indicates the possibility of exploration developing other ore-shoots. A heavy fault plane is often in evidence in the workings, the gouge being frequently several inches thick. Considerable brecciation of ore has occurred, indicating faulting subsequent to ore deposition. The best ore is a bright red porphyry or syenite through which there are ribbons of quartz carrying tellurides, copper pyrites, iron pyrites, molybdenite, graphite, calcite, and native gold. The vein is principally in the porphyry and syenite that lies adjacent to a band of conglomerate, greywacké, and quartzite, in which the shaft has been sunk entirely from above the 300 ft. level to the 700 ft. level. The dip of the contact is approximately the same as that of the vein, or about 85° S. The north fault plane or foot-wall of the vein is sometimes in the sedimentary formation. High-grade ore with visible gold was observed on the 400 ft. and 500 ft. level stopes, which, together with a lower grade, is expected to average approximately $10 a ton. The ore is hoisted in the main shaft, passed through a crusher, and carried to the mill bin on a conveyor belt. The mill treats 140 tons per day and the recovery is 92 to 95 per cent.

Orr.—The main fracture of the area passes from the Kirkland Lake mine across the north-west corner of the Orr claim, otherwise known as the Orr-Wettlaufer, and extends to the Teck-Hughes and Lake Shore on the north-east. The vein on the Orr property was discovered in 1913 and some work done. In 1917 the property was optioned to the Kirkland Porphyry, and considerable underground work was done. Ore was developed on the 280 ft. and 400 ft. levels during 1918. In 1919 a long cross-cut, 700 ft. in length, was driven on the 400 ft. level to the south-east to reach a parallel vein that outcrops 575 ft. to the south. The cross-cut was thought to be within a few feet of the objective in June, 1919, when the miners went on strike and all work was suspended. The main No. 1 vein, on which some ore has been developed, is approximately 300 ft. in length on the surface and 400 ft. on the fourth level, the gain in length being due to the vein dipping approximately 83° to the south. A vertical shaft has been sunk to a depth of 420 ft. On the 150 ft., 240 ft., 280 ft., and 400 ft. levels the vein has been cross-cut at 12 ft., 18 ft., 23 ft., and 50 ft. respectively, to the south of the shaft. The vein is similar in character and structure to the main vein on the adjoining properties. For a depth of about 300 ft. the vein is on or near the contact between the sediments and a red hornblende syenite. The shaft at a depth of 310 ft. passed from conglomerate into syenite. On the 400 ft. level the vein in places is entirely in the syenite, while in the west work-

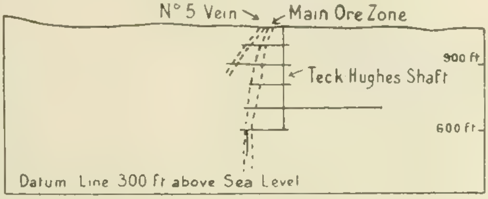


Plan of Orr Mine at 400 ft. Level

ings it is in the contact between quartzite and syenite. There are two main faults from 12 ft. to 25 ft. apart, along and between which the ore occurs. A central fault is also quite pronounced, and there are numerous minor slips. A narrow drift 400 ft. in length has been driven along the central fault in ore. Several cross-cuts on this level show that there is high-grade across narrow widths on both the hanging wall and foot-wall. The high-grade is comprised of silicified porphyry with numerous molybdenite streaks and much iron pyrites, chalcopyrite, altaite, and gold.

Teck-Hughes.—The main ore-bearing zone of the Kirkland Lake area passes through a southern portion of the Teck-Hughes property, where it is known as vein No. 3. The bulk of the gold produced at the mine, namely $316,882 up to the end of 1919, has come from this vein. It occurs largely in the porphyry and syenite, but passes for several hundred feet along the contact between the intrusives and the conglomerate. Practically all the early development work in 1913 was done on vein No. 1, which lies about 100 ft. north of the main zone. The main vertical No. 1 shaft at the east side of the property was commenced on vein No. 1, which dips 80° to the south. The vein is composed of brecciated porphyry and quartz from 2 ft. to 6 ft. wide and carries low contents of gold. Shafts Nos 2 and 4 are to the west on a narrow vein in the conglomerate which may be a continuation of the No. 1 vein. This vein resembles the vein in the conglomerate on the Ontario-Kirkland. No. 3 shaft near the south boundary of the claim has been sunk 200 ft. on the main ore deposit with winzes down on ore to the fourth level. Cross-cuts from the No. 1 shaft have cut the main No. 3 ore zone at distances ranging from

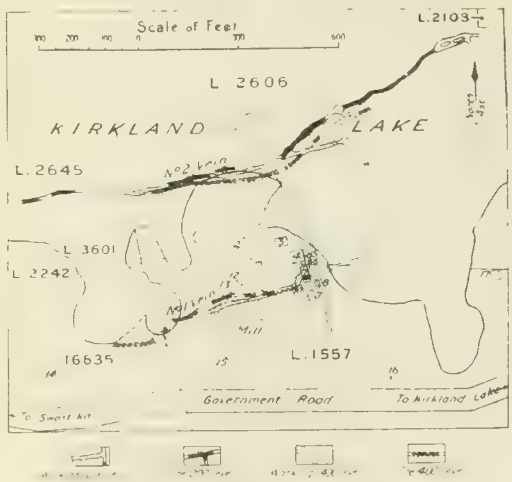
100 ft. to 170 ft. to the south. Drifts, each approximately 1,000 ft. long, extend along the main zone on the second, fourth, and fifth levels. A cross-cut to the vein has been made on the sixth level. Over 10,000 ft. of underground work has been accomplished to date above the 600 ft. level. The section shows the workings and ore-shoots on the main vein, as recognized up to March, 1920. Vein No. 5 is a branch from the hanging-wall side of the main vein and dips about 60° to the south. The ore in the main No. 3 vein, which is typical of the ore described on other properties, occurs in shoots usually between two prominent, nearly parallel mud seams or faults, from 6 to 40 ft. apart, and dips 85° to the south. The faults or slips are often filled with gouge from an inch to six inches in thickness, narrowing down in places to mere cracks. In many places secondary minerals such as quartz, calcite, and reddish barite fill the faults. The ore, which is similar to that on the adjoining properties, is comprised of brecciated syenite, porphyry, and quartz cut by veinlets of quartz, the whole containing numerous slip planes. The minerals present are pyrite, copper pyrites, molybdenite, altaite, and gold.



CROSS SECTION OF TECK-HUGHES.

The ore-shoots are irregularly distributed throughout the faulted zone. Usually the shoots lie on the inside and adjacent to one of the main fault walls. In places, however, the ore is continuous between the two fault walls, while in other places the ore extends out beyond a fault wall. Two or three main faults are apparently subsequent to the ore deposition, but act as guides in following the ore. The shoots range in size from a few feet to over several hundred feet in length, being at times over 40 ft. in width. It has been found that the best ore usually occurs where the faults are a considerable distance apart, or where there is a sharp roll in the dip along the main faults. The south or hanging wall has produced more ore than the foot-wall. The values are so erratic that the careful sampling of every face or round is required to locate the ore-shoots. Stoping, however, has shown that the values are not so uneven as lateral work would indicate. In 1917-18 the ore averaged $7·87 per ton, which was a lower value than was indicated by the underground sampling. This was due to a dilution with waste rock caused by the easy breaking qualities along numerous slips in stoping. Ore, however, occasionally extends behind one of the fault planes or the supposed ore wall, hence horizontal drill-holes are put in at regular intervals beyond the supposed ore wall for testing purposes. The west shoot was found to extend from the surface to the fifth level and to be still continuing as shown on the section. The values in the large stope above the 400 ft level near the eastern boundary of the property were more even than in the other ore-shoots. The fractured zone between the ore-shoots assays from 40 cents to $4 00 in gold, per ton ; hence the grade of ore varies according to the amount of lower-grade material that is mined with the higher-grade.

Lake Shore. — The Lake Shore Mines property is a consolidation of five claims along the main fracture zone that passes through Kirkland Lake. It includes an area on the south side of the lake and also the southerly part of the lake bed itself. The first work was done on No. 1 vein on the south shore of the lake, where a vertical shaft has been sunk to a depth of 400 ft. and drifts run on the 100 ft., 200 ft., 300 ft., and 400 ft. levels, the greatest amount of work having so far been done on the third and fourth levels. Development has shown that the vein dips slightly to the north above the 200 ft. level. A strong fault was encountered just above the 200 ft. level, dipping 25° to the south. The fault displaced the vein a distance of 28 ft. From the 200 ft. level to the 400 ft. level the vein is nearly vertical. The 400 ft. level is also connected with the surface by rises. With the exception of a small amount of ore from back-stoping and rises, all the ore obtained from No. 1 vein has so far been taken from the drifts. The ore occurs chiefly in the reddish porphyry, but parts of the vein have conglomerate and lamprophyre as wall-rocks. Owing to the small amount of cross-cutting the distribution of these bands of other rocks has not been worked out.



PLAN OF WORKINGS, ETC., LAKE SHORE MINE

1 Thaw house
2 Carpenter shop
3 Boiler house.
4 Compressor and hoist house.
5 Transformer house.
6 Water tank.
7 Shaft house.
8 Dry
9 Crusher house.
10 Blacksmith shop.
11 Lime house.
12 Assay office.
13 Refinery
14 Manager's residence.
15 Office and store room.
16 Meter house.
17 Bungalow.

On the 200 ft level, 100 ft. west of the shaft, lamprophyre has been faulted over porphyry. A strong cross fault, 310 ft. west of the shaft, on the 400 ft. level, striking nearly north and south and dipping nearly vertically, has displaced the part of the vein lying to the west of the fault 20 ft. to the south. This fault is also indicated in the workings in the west drifts on No. 2 vein. The work on the vein in the vicinity of this fault was rendered difficult by the occurrence of several subsidiary faults.

Cross-cuts have been run from the shaft northwesterly on the 200 ft. and 400 ft. levels to intersect No. 2 vein under the bed of Kirkland Lake. This vein is on the main fracture that is being developed at a number of mines over a distance of 2¼ miles. It has

been driven on north-easterly and south-westerly from the cross-cut on each level, the greatest amount of driving having been done on the 200 ft. level. Here the vein is opened up for a distance of 1,500 ft., for the greater part in ore. With the exception of some back-stoping, preparatory to timbering for mining, the ore extracted has come from development. Red felspar-porphyry and syenite occur with the vein over most of the distance so far developed, but in the west drift, 330 ft. from the cross-cut, this rock is associated with bands of conglomerate and lamprophyre to the face of the west drift (April 15, 1920), about 800 ft. from the cross-cut. The west face is entirely conglomerate, and for a distance of about 150 ft. the vein is in this rock and is of commercial grade. Ore also occurs where lamprophyre is the wall-rock. Development on the 400 ft. level is similar to that on the 200 ft. level, the vein where opened being principally in the red porphyry and syenite with conglomerate showing in the west drift. A long stope has been opened on this level and at the time of visit was almost through to the 200 ft. level. Fracture planes occur along the vein, the ore-body showing slickensided, nearly vertical walls with a slight dip to the south. The ore is largely of the red porphyry type, associated with which is quartz in lenticular masses and ribbon-like structures. Brecciation of the ore is evident in the fractured character of the porphyry and the vein quartz. Minor slip planes occur along the ore-body, and commercial values sometimes cease at one of these slips and come in again on other slips in driving along the vein. Constant assaying of faces is necessary, since the ore sometimes turns off, from where it has been following a well defined wall, diagonally along another wall. In addition to the fracture planes with which the ore is associated there are heavy faults showing much clay gouge in places that in part have followed the ore-bodies, and again are not near the ore-body. One of these faults was driven on for 210 ft. easterly from the cross cut on the 200 ft. level, being mistaken for the vein. Later it was discovered that the ore-body had turned off from this heavy fault 40 ft. from the cross-cut on the north side. Beyond this it was followed north-easterly for several hundred feet nearly to the Wright-Hargreaves boundary. The ore-bodies vary in width, and it is difficult to determine the widths along the drifts, which are usually about 5 ft. wide, and frequently all in ore. Much of the ore in the 400 ft. stope on No. 2 vein will average 11 ft. in width. In mining in the stopes the walls are tested by horizontal drill-holes at regular intervals and the stoping continued to the boundary of the ore.

Wright - Hargreaves.—The Wright - Hargreaves mine is situated on the main ore-bearing fracture near the centre of the productive area, where the porphyry rocks have the greatest exposed width in the area. The mineralized zone has been traced intermittently for 2,400 ft. on the surface, and it undoubtedly extends for 1,500 ft. across the western part of the property, which is covered by a portion of Kirkland Lake and passes to the Lake Shore mine on the west. The zone is roughly parallel to the longer boundaries of the property. It was in veinlets in this fracture that gold was first found in the area in 1911 by W. H. Wright. During that autumn two core-drill holes were put down on the vein with a shot-drill. The holes were driven only to shallow depths, partly on account of the hardness of the porphyry. Cartwright took an option on the property, and in 1913 discovered a small rich vein about 550 ft. north of and parallel to the main vein. A 60 ft. shaft was sunk on this vein, which is 5 ft. or 6 ft. wide, and also in the porphyry, from which 3·4 tons of ore was shipped giving returns of $331 to the ton. The option was allowed to lapse, and the property lay idle for a long time before the present Wright-Hargreaves company commenced operating. Two shafts about 950 ft. apart have been sunk on the main fracture to the 300 ft. and 400 ft. levels respectively, and a drift on the 300 ft. level to connect these shafts is about half completed. The vein and ore are very similar to those of the Lake Shore. The vein varies in width from a few feet to over twenty feet. The north, or No. 2 vein, is similar in appearance to the main vein. The strike of the western portion of the vein suggests that it may be a branch from the main vein. This No. 2 vein where located at the 300 ft. level by a long cross-cut from the main shaft was reported to contain high-grade ore over a stoping width. The vein at this point occurs slightly to the north of the vertical projection of the 60 ft. shaft, which would indicate that the vein either dips to the north or has been faulted in that direction. The underground workings of this mine were filled with water at the time of inspection, but the owners state that ore of good grade occurs in a number of faces. Sufficient work has not been done to show the sizes and number of ore-shoots. However, the property gives promise of becoming a substantial producer. A 175 ton mill was commenced in the spring of 1919, but owing to the miners' strike during that summer all work was suspended until May, 1920.

Tough-Oakes.—The property was the first to be operated in the area following the discovery, in January, 1912, of gold-bearing veins in the porphyry and conglomerate. It consists of five claims situated along the boundary lines between Teck and Lebel townships. Surface prospecting in the early years of the mine resulted in the finding of 11 veins in the porphyry, greywacké, and conglomerate, some of the veins passing from one to the other formation. The veins are roughly parallel with the average strike, somewhat south of west. The principal development has been on veins Nos. 2, 3, and 6, the first two producing most of the ore already taken from the mine. The veins were traced on the surface by trenching. No. 2 vein was traced for 370 ft.; No. 3 for 830 ft.; No. 6 for 1,460 ft., entirely in porphyry, with 740 ft. of it showing an assay-value of about $12 per ton for a width of 60 in.; No. 7 was trenched for 245 ft. in the greywacké, the quartz rib of which averaged 18 in. with stringers in both walls. In the first three years of operations high-grade ore was hand-sorted and shipped to smelters. The richness of the ore can be judged from shipments. In 1912 and 1913, 101 tons with a value of $46,221, or $457 per ton, were shipped to smelters. In 1914, 212 tons, with a value of $781,590·38, or $350 per ton, were shipped. After being hand-sorted the remaining ore was treated in a 5-stamp mill by amalgamation, with a recovery of 55%. The tailings from this treatment were impounded, and later treated in the new 100 ton cyanide plant in operation in March, 1915. The operations of the small stamp-mill may be judged from the statement that during 1914 there were treated 3,493 tons of ore with a head value of $22·35 per ton for a recovery of $43,353. The ore raised from the mine in 1914 had an average value of $41·18 per ton.

The veins that were developed were comparatively narrow, and the average stoping width was about 5 ft. An idea of the value of the ore along drifts is obtained from statements in annual reports of the company. For instance, in No. 2 vein one section of ore on the 200 ft. level had an assay-value of $78 for a length of 218 ft. and width of 65 in. A section on the same vein on the 300 ft. level showed an assay-value of $32 over 65 in.; 180 ft. of driving on vein No. 3 on the 200 ft.

THE LAKE SHORE MILL

level had an assay-value of $32 over a stoping width of 63 in. The early development was on No. 2 vein, the first work being an open-cut, from which the first shipments of high-grade ore to smelters were made. An incline shaft (A) was then sunk on the vein, which has a dip of 55° south, and the main ore-shoot developed on four levels. The workings that started in conglomerate passed into porphyry and the high-grade character of the ore was maintained. In driving westward on different levels the vein was found to be faulted by a basic dyke a few feet in width that strikes N. 20° W., and dips nearly vertically. Within the dyke there are heavy fault planes. The dyke was encountered 295 ft. west of the shaft on the 200 ft. level. The extension of the vein on the west side of the fault has not been determined definitely; one theory is that No. 1 vein, exposed on the surface 340 ft. south of No. 2 vein, is the faulted portion of No. 2 vein. High-grade ore in No. 2 vein was cut off abruptly against the dyke, and consequently the solving of the fault problem is of great importance to the mine. The dyke is known to have displayed a strong east and west fault, dipping 87° S. on the Burnside to the south, a distance of only about 8 ft. horizontally; while No. 11 vein, with a dip of 80° S. on the Tough-Oakes 180 ft. north of No. 2, has been apparently faulted only very slightly. In view of these facts it is probable that the displacement has been largely in a vertical direction. The main ore-shoot on No. 2 vein has a stope length of about 250 ft. on the 300 ft. level. The easterly margin of the ore-shoots indicates a pitch to the west. Ore-shoots were also developed on subsidiary veins to No. 2. Shaft B was sunk on No. 3 vein, which also dips to the south, and development continued below the 100 ft. level by means of a number of winzes to the 400 ft. level. The main ore-shoot on No. 3 vein also pitches to the west. No. 6 vein and other parallel veins near No. 3 vein were also opened from the workings at B shaft. The workings on No. 3 and parallel veins are connected with A shaft on No. 2 vein by a long cross-cut on the 200 ft. level. The ore from different parts of the mine is hoisted through the A shaft. Since the amalgamation of the Burnside with the Tough-Oakes, No. 2 shaft (vertical) on the Burnside has been deepened and connected with A shaft on the 400 ft. level by a long cross-cut. This shaft will be used for handling men and supplies. C shaft, sunk to the 100 ft. level on vein No. 1, and shaft No. 3 on the Burnside are not as yet connected with the main workings of the Tough-Oakes.

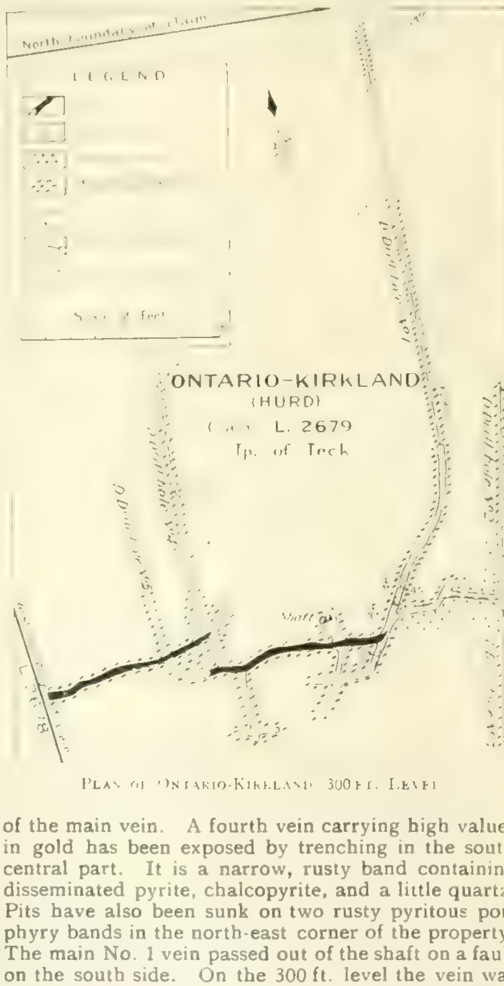
PART OF THE TOUGH-OAKES PROPERTY

Sylvanite.—This property lies between the Wright Hargreaves and Tough Oakes mines with workings in the felspar porphyry along fracture zones. The property was not in operation in 1919, but during 1917 a shaft was sunk to a depth of 120 ft. and 169 ft. of cross cutting and driving was done on the 100 ft. level. The mineralization as exposed where the vein is stripped on the surface is similar to other occurrences, where altered porphyry with quartz veinlets form the ore.

Kirkland Combined.—The Kirkland Combined Mines is operating the Day Claims which adjoin the Sylvanite on the north, and corner the Tough-Oakes on the north-west. These two claims were formerly known as the Wishman claims, and considerable trenching and surface sampling were done in 1913. The claims, which were allowed to revert to the Crown, were restaked and operated in the autumn of 1919 by the Kirkland Combined Mines. Air was delivered from the electrically driven compressor on the Sylvanite. The west claim is practically all lamprophyre, while the east claim, on which most of the work has been done, has about equal proportions of conglomerate, lamprophyre, and porphyry. Extending along the porphyry-lamprophyre contact and passing into the lamprophyre to the west is a pronounced fracture zone, which is 5 ft. wide and traceable on the surface for over 500 ft. in an east-west direction. Veinlets of quartz and considerable iron pyrites and some molybdenite occur in the fault zone. Samples yielding low gold contents on assay have been obtained from a few places in the vein. By diamond-drilling it was found that the fracture zone was mineralized with pyrite to a depth of about 200 ft. At a point on the surface where the vein passes from the lamprophyre into the porphyry-lamprophyre contact a vertical shaft was sunk to a depth of 200 ft. and a 106 ft. cross-cut driven to the south. The vein passes out of the shaft on the south wall at a depth of 85 ft. In the cross-cut on the 200 ft. level two nearly parallel mineralized fractures were encountered, 20 ft. and 40 ft. respectively south of the shaft upon which driving is being done, the south fracture being on the porphyry-lamprophyre contact.

Black.—The Black claim lies immediately south of the Wright-Hargreaves east claim. Near the north boundary is a vein striking north-east in the conglomerate, on which a shaft has been sunk to a depth of 155 ft. No mining was being done in the summer of 1919, but the vein, which is mineralized conglomerate with quartz stringers, is lenticular and narrow. It is said to contain in places high-grade ore over a width of 4 or 5 inches.

Ontario-Kirkland.—The Ontario-Kirkland Gold Mines owns two claims, formerly known as the Hurd, which are situated about three-quarters of a mile south of the central ore zone of the Wright-Hargreaves. These claims were optioned during the early part of 1917 to the La Rose Mines, who stripped and sampled a part of the surface and sank a 100 ft. shaft on the main vein, after which the option was dropped. The present company continued the shaft to a depth of 300 ft., where 1,000 ft. of driving and cross-cutting and 930 ft. of horizontal diamond-drilling have been done, resulting in the finding of some ore. Recently (May 23, 1920) the shaft reached the 450 ft. level, where two gold-bearing veins were encountered at points 25 ft and 37 ft. respectively south of the shaft, and upon which additional lateral work is being done. The rocks consist of schistose conglomerate and greywacké, which have been intruded by typical reddish felspar-porphyry. The largest porphyry mass in the area extends across the northern part of the property. It is 250 ft. wide on the surface and one-half that width where it has been pierced by a diamond-drill hole on the 300 ft. level. The porphyry in the south-west part is unusually schistose. Six veins have been found on the surface, all of which are practically vertical, with a nearly east-west strike. They occur largely in the sediments. Two extend from the conglomerate into the porphyry, while another is entirely in the porphyry. The main No. 1 vein, on which most work has been done, has been traced for 400 ft., the western part in a yellowish sediment resembling altered porphyry schist. At the shaft the vein passes into conglomerate, and farther east it has been faulted and probably extends into the porphyry. Two narrow short veins occur about 60 ft. and 80 ft. respectively to the south



PLAN OF ONTARIO-KIRKLAND 300 FT. LEVEL

of the main vein. A fourth vein carrying high values in gold has been exposed by trenching in the south central part. It is a narrow, rusty band containing disseminated pyrite, chalcopyrite, and a little quartz. Pits have also been sunk on two rusty pyritous porphyry bands in the north-east corner of the property. The main No. 1 vein passed out of the shaft on a fault on the south side. On the 300 ft. level the vein was located at a point 25 ft to the south of the shaft, and driven on for 180 ft., over which length the values were reported by the manager to average $12 in gold per ton across 5 ft. The deposit consists of altered conglomerate and greywacké, quartz veinlets, iron pyrites, copper pyrites, and some molybdenite. Little gold is visible. The ore has been cut off at both ends by faults. The portion of the vein to the east of the fault has not been definitely located, but a mineralized porphyry fault zone in the north-east cross-cut may be this extension. To the west of the west fault a some-

what similar ore deposit, but not necessarily the continuation of the No. 1 shoot, has been located 35 ft. to the north. A drift on this deposit for a length of 150 ft. was reported to average $17 per ton across 6 ft.

Montreal-Kirkland. — These claims are situated south of the Ontario-Kirkland. A shaft has been sunk on claim number L. 6681, but was full of water at the time of inspection.

Hunton.—The Hunton property is situated nearly a mile south of the south-west end of Kirkland Lake and consists of two claims. A porphyry dyke with strike N. 66° E. intrudes the schistose sedimentary rock near the line between the claims; most work has been done so far on the northerly claim. A mineralization occurs along the south contact, extending into both formations. An open-cut was made along a series of narrow quartz veinlets 1 in. to 3 in. wide, which intersect the sediments and porphyry, the cut passing from the sediments to the porphyry to the north-east. A shaft was sunk to a depth of 40 ft. in the sediment with the porphyry on the north wall. The mineralization is reported to extend to the bottom of the shaft, while visible gold was encountered down to about 30 ft. Diamond-drilling indicated gold in the core from a depth of 254 ft. from the surface, vertically. By open-cuts and pits the mineralization has been traced for 300 ft. along the surface. Just north-east of the shaft three quartz stringers dipping south are exposed in the open-cut; while 25 ft. from the shaft there is a quartz vein 2 in. wide running diagonally across the trench, N. 30° E. in the porphyry, carrying extremely rich showings of gold with pyrite. The gold is very fine, almost like mustard gold, and shows as a yellow stain throughout the quartz. The porphyry and quartz along the rich streak carry abundant iron pyrites. This mineralization is adjacent to a fault plane that strikes in the same direction as the vein.

Chaput-Hughes.—A power plant has been installed on this property and a shaft has been commenced.

Honer.—This property is just west of the Hunton. The rocks are sediments intruded by narrow dykes of red porphyry striking north-east and south-west. Several quartz veins have been found, the principal one of which is in the south-west part of the claim. It has been traced about 300 ft. and prospected by means of several pits and a shallow prospect shaft. It occurs in schistose sediment on the north-west side of a porphyry dyke. Where seen in one pit the structure shows a somewhat banded character of quartz veinlets in the sediment over a width of 6 ft., with the wider quartz bands toward the centre of the deposit. The quartz veins dip 70° to 80° S.E., and the best values are reported to occur in the foot-wall side in the narrow seams of quartz. The principal metallic sulphide is iron pyrites. A working shaft was being sunk near the north-east end of the exposure of the vein.

Canadian Kirkland.—The property is situated a few hundred feet south of the Swastika-Kirkland Lake road, 1¼ mile south-west of Kirkland Lake. The surface exposures are schistose sediments, conglomerate, greywacké, and slate, intruded by narrow dykes of red felspar-porphyry and a younger diabase dyke that runs south-west through the property. There is a thin mantle of drift on much of the surface, requiring trenching to expose the rocks. Two vertical shafts and several pits have been sunk on mineralized zones. The main shaft was sunk on a mineralized zone in the greywacké, consisting of quartz veinlets and greywacké impregnated with iron pyrites, copper pyrites, galena, and calcite. The strike of the mineralized zone is E.N.E. and W.S.W. A section exposed in the shaft shows a series of quartz veinlets about one inch wide, dipping steeply to the south across the shaft to the 150 ft. level. A short cross-cut was made southward at the 100 ft. level, and on the 150 ft. level a cross-cut was made to the north and south of the shaft. Promising assays were obtained for about 85 ft. in the shaft, but no driving was done to determine whether the mineralized zone pitched eastward or westward. The cross-cut at the 150 ft. level is in greywacké with fine-grained slate-like rocks 85 ft. south of the shaft.

THE NEW CITY DEEP SHAFT.

At the meeting of the Institution of Mining and Metallurgy held on February 17, a paper by E. H. Clifford was presented describing the City Deep South Shaft which is being sunk to a depth of 7,000 ft. in order to work the deepest parts of the gold-bearing reef on this property.

The claims of the City Deep cover an approximately rectangular area 2·3 miles along the strike by 1·2 on the dip. The Main Reef Leader, which is virtually the only reef worked, lies at a depth of about 2,000 ft. at the top or northern boundary, and at the southern boundary its depth probably ranges between 6,600 ft. and 7,300 ft. The mean dip is rather less than 40°. The mine is now being operated from two vertical rectangular seven-compartment shafts, 4,000 ft. apart, having depths of 3,300 ft. and 4,000 ft. respectively. From the bottom of these shafts there extend two five-compartment inclines which underlie the reef and are connected with it by cross-cuts at each level. The inclines have two double hoisting ways and a ladder and pipe compartment. The West Shaft has reached the 20th level and the East the 18th level; the vertical depth of the 20th level being 4,950 ft. In addition, there is a ventilating shaft 2,200 ft. deep near the northern boundary. The monthly output is about 80,000 tons. While incline shafts of short length and in firm ground are an excellent means of opening a mineral deposit inclined at a dip less than 45°, it is found in practice that they become unsatisfactory under opposite conditions. On account of the difficulty of filling very large skips, it is not possible to increase loads indefinitely, nor is it possible to reach the winding speeds that are common in vertical shafts, consequently the shaft capacity falls away very rapidly when a certain length is reached, usually about 3,500 ft. Furthermore, inclines are difficult to manage, and expensive to sink and maintain, in bad ground or where the pressure becomes heavy, and obviously this difficulty is most serious where the span is large. The City Deep inclines will before long not only have reached the vertical depths at which troubles with rock pressure are likely to become serious, but at the same time their length will also have reached the economic limit. In this instance, the latter will be about the 22nd level, at a vertical depth approximately 5,300 ft. below the surface. There will remain, therefore, an area equal to about one-third of the property which is not provided for by present appliances, and the problem was how to exploit it. Briefly, the scheme adopted consists in sinking a vertical shaft of circular section 7,000 ft. in depth, in two stages of 4,500 ft. and 2,500 ft. respectively. The upper section will stop at the 17th level, where it will make connection with the two incline shafts, and the reef will be attacked from the lower section of the shaft by cross-cuts at each level.

The capacity required of the shaft is 2,000 tons of ore per 24 hours plus all the men, natives, and materials

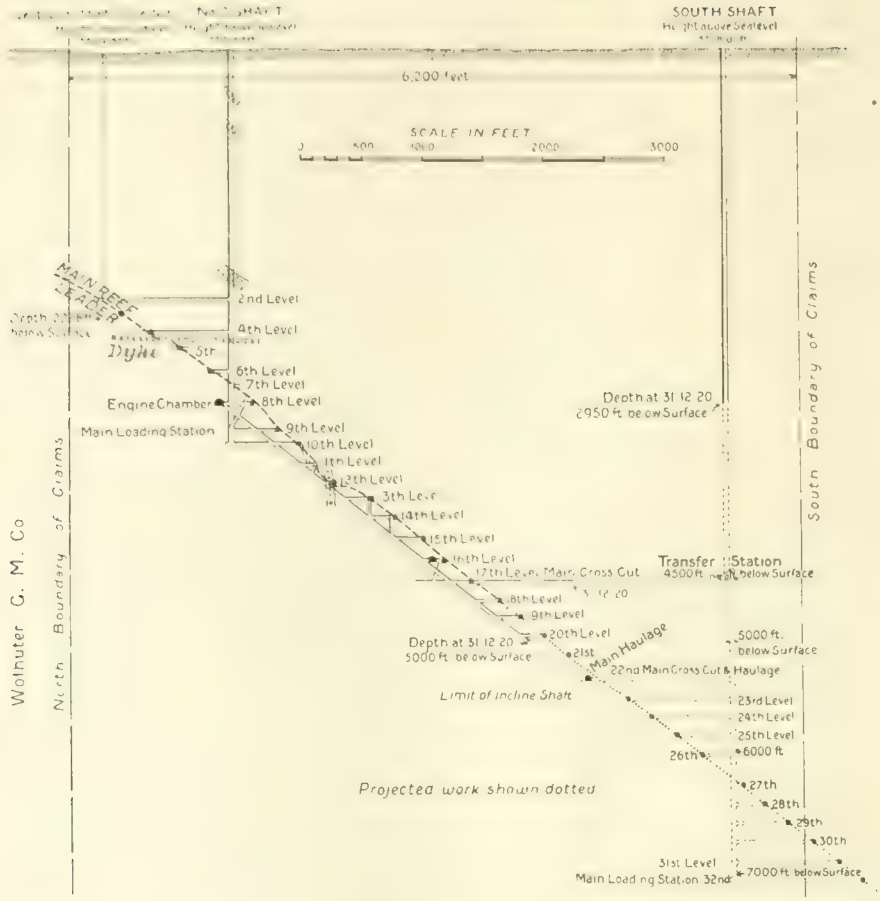


FIG. 1. VERTICAL SECTION OF CITY DEEP SHOWING POSITION OF NEW SHAFT.

necessary for this output, together with a liberal allowance for contingencies. In addition to this the shaft must be capable of carrying 300,000 cu. ft. of air per minute, without undue consumption of power. It may be questioned whether it would not have been preferable to divide the distance into two equal portions of 3,500 ft. each, thus requiring a moderately large winder on the surface instead of a very large one. The reply is, that the heat released by an electric winder located underground is a serious matter, therefore the smaller it can be made the better. The total heat produced is equivalent to the difference between the total electrical input less the net work of raising the rock, and with the size of winder required for a depth of 2,500 ft. the loss would be about 18,000 B.T.U. per minute while the winder is at work. This considerable quantity of heat can only be got rid of by conveying it to the air, and as it is most desirable that it should be kept away from the lowest workings of the mine, some 75,000 cu. ft. of air per minute must pass through the engine and converter set chamber and along the 17th level cross-cut. In regard to the hoisting of the ore, the work is well within the capacity of one engine, and in view of the enormous cost of large electric winders at the present time, to say nothing of operating costs and duplication of shaft equipment, it is obvious that this is an important consideration. Using a single engine, however, necessitates an alternative route both for men and materials, and this is provided for by means of the 17th level cross-cut which is directly connected with the western incline shaft, and also by means of a main transport drive, with the eastern or No. 1 incline. The transport drive is some distance below the reef and therefore out of harm's way when the stopes cave, and both it and the cross-cut will be equipped with an overhead electric locomotive system. It will thus be possible to bring any ore in the mine to the 17th level, whence it can be diverted to either of the two present winding shafts or to the new main shaft. This elasticity, which is almost complete, is an extremely desirable condition and worth a great deal of trouble to attain. It safeguards the continuity of the mine output in case of accident to any of the shafts and renders possible the laying-off of either of the old main shafts when the output of ore in its neighbourhood becomes too small to keep it busily employed.

The shaft is 20 ft. in diameter in the clear and is fitted with concrete rings spaced at 10 ft. vertical intervals, each ring being 18 in. deep by 15 in. wide. The function of the rings is to provide adequate fastenings for the shaft guides, pipes, cable, etc., and also to afford a foundation for any kind of lining, such as bricks or monolithic concrete, should such lining be found necessary. In this particular case 22 sections near the surface were

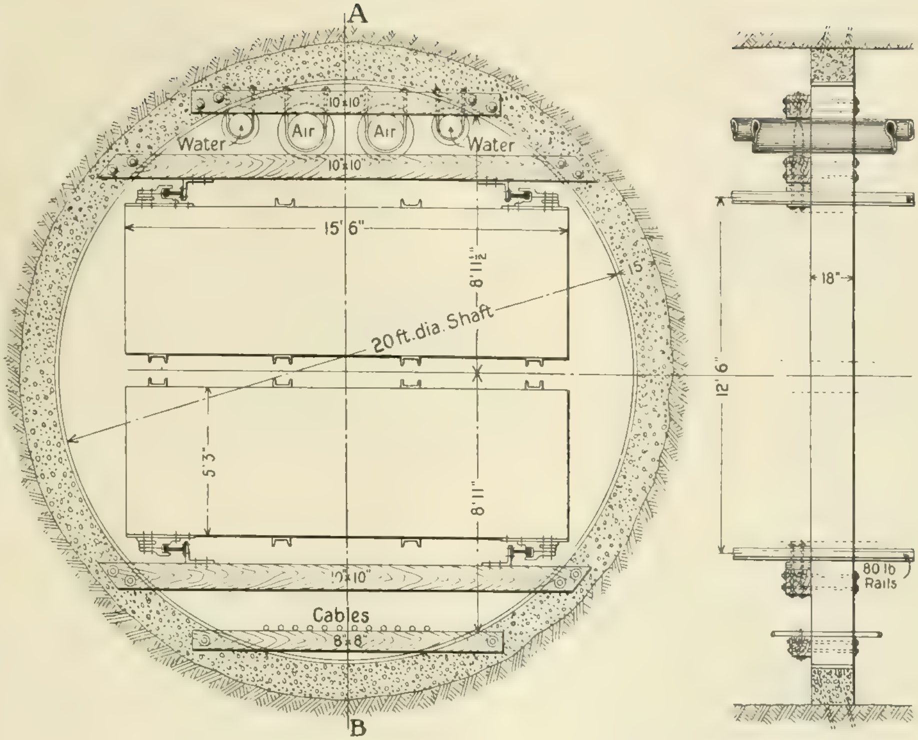


FIG. 2. CROSS-SECTIONS OF THE CITY DEEP SHAFT.

so lined, but the remainder of the shaft as far as it has gone at present needs no support, although it is quite possible that signs of local deterioration may show themselves subsequently, in which case the remedy will be simple. The rocks of the Witwatersrand System are, for the most part, extremely strong and rarely need support, at least in a vertical shaft. The concrete forming the rings is moulded round steel pegs about 20 in number and 24 in. long, driven into drill-holes in the rock. The guides are 80 lb. standard section flat bottom steel rails specially strengthened and fastened to 10 in. by 10 in. pitch pine dividers connected by special fish-plates machined to ensure accurate registration at the joints. It will be observed that the base of the guide rails is at right angles to the divider and not bolted to it directly. The latter method, which results in the heads of the rails facing outward, commonly referred to as the Briart system, necessitates the use of a guide shoe embracing the head of the rail, obviously requiring great accuracy of gauge. This accuracy is not easy to achieve during installation, and still less easy to maintain. The method used in this instance, without sacrificing strength or safety, admits of some latitude in gauge and a simple adjustment for wear. The dividers are placed at the sides instead of one divider in the middle, as the latter scheme necessitates long and rather fragile girders which are bound to be damaged by an accident to either cage, thereby probably putting both cages out of action. Another rather serious objection to a central divider is that it prevents the use of a stage for shaft repairs, an important point in a shaft not provided with ladders. It will be noticed that this form of construction admits of scarcely any timber being used in the shaft equipment, a most important consideration in view of the necessity of keeping the shaft absolutely dry. A timbered shaft should be either wet or dry; if it is damp the timber rots, and if it is alternately wet and dry the shrinkage of the wood leads to continual difficulties in the alignment of the guides. Furthermore, a dry timbered shaft is in perpetual danger of fire. In this instance, wood has not been entirely dispensed with, since, when repairs are necessary, it is a much more convenient material to work with, as anybody who has had experience of an accident to steel-work in a shaft well knows. The position of the guides with relation to the cage is not perhaps ideal; a symmetrical disposition at the centres of the ends would, from this point of view, have been better, but this arrangement would entail the breaking of the guides at landing stations, which is a dangerous practice, and also necessitates short guide shoes which cannot be strongly fastened, instead of the shoes shown, which, if need be, may be made the whole length of the cage.

The concrete rings are moulded in plain steel forms, 20 ft. in diameter, made for convenience in handling in seven sections, which are suspended from the last ring up. The bottom of the form is filled with short lengths of wood to hold the concrete. The filling and removal of the forms is, of course, done from the stage and does not interfere with the sinking. The plumbing arrangements are carefully carried out and consist of a gallery under the collar of the shaft, equipped with four permanent geared winches and $\frac{1}{16}$ in. stranded steel plumb-bob wire. It takes very little time to check the concentricity of the rings and give the sinkers their marks. The lay-out at the transfer station is shown in Fig. 3. By means of hydraulic pushers the cars are transferred from cages to traversers operated from a continuously moving rope by ordinary tramway clips. The track arrangements provide all necessary facilities for trans-

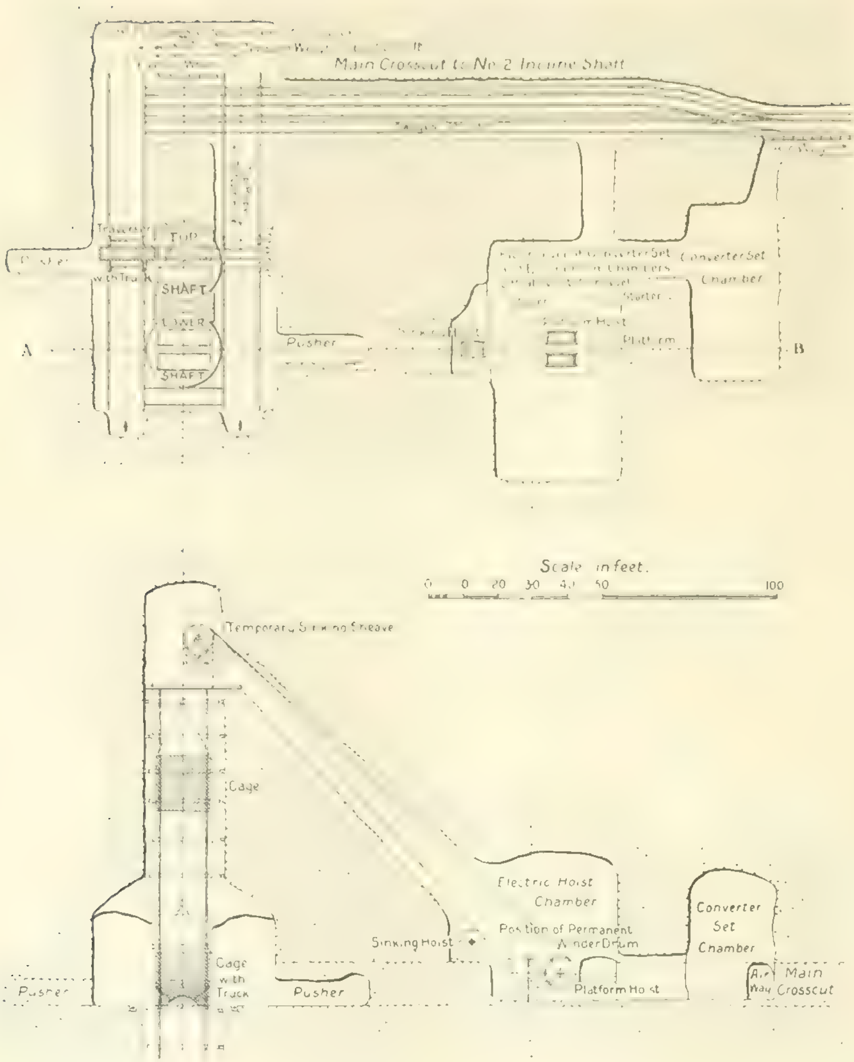


Fig. 3. Plan and Elevation of Internal Hoisting Installation.

ferring cars, both fulls and empties, either direct to the surface or through the cross-cut to No. 2 shaft and vice versa.

The cage is 15 ft. 6 in. by 5 ft. 3 in., with two decks. It is intended to make it of alloy steel, as the saving in weight thereby effected will, in this instance, materially increase the working life of the winding ropes, diminish the consumption of power, and more than compensate for the additional cost. The rock will be carried in a single 8-ton bottom discharge truck in the lower deck, the upper deck being provided for men, the load amounting to 50 on each deck, or 100 in all. The great length of the cage will permit of timber, drill steel, and other stores being taken to their destination in the mine on trucks without any rehandling at the landing stages, an important matter in saving time. The condition determining the size of the equipment is, in this instance, capacity in handling men and material rather than rock-hoisting capacity. The rejection of skip-winding and the adoption of the cage and truck system is a departure from standard practice in this and most other metalliferous districts. The great advantage of skips is, of course, their low tare and ease of loading or unloading. The first advantage is undoubted, but the latter does not show up so well when compared with truck loading into cages by power, especially if the units are large. The disadvantages of skips are, their very low capacity for men and materials, the greater danger of overwinds, and the fact that they do not permit of a large capacity in the headgear ore-bins unless the headgear is built of an inordinate height. The men and material question can be overcome either by duplicating the winding plant or by interchanging cages for skips, but both these remedies are subject to obvious disadvantages. In this

particular instance, skips show still less advantage because at the transfer station on the 17th level it is obviously easier to send ore already in a truck either direct to the surface through the South Shaft or to the other shafts, and vice versa, than it would be to do the same thing if the ore had to be taken from or put into a chute. This could only be done by branch chutes with deflecting doors, which, although satisfactory enough for small tonnages, are a source of continual trouble when the tonnages are large.

THE GREENAWALT SINTERING PROCESS.

In the *Mining and Scientific Press* for January 15, W. E. Greenawalt gives a description of the sintering process and plant invented by J. E. Greenawalt, of 50, East 42nd Street, New York. A number of these plants are in use, the largest, having a capacity of 2,000 tons per day, being employed in sintering magnetite concentrate and flue-dust from iron blast-furnaces respectively. The process, as practically developed, is intermittent in operation. A charge of the material to be sintered is placed in a pan-shaped furnace and subjected to a down-draft blast of air; the upper surface of the charge is ignited and the sintering action proceeds through the charge from the top downward. After sintering, the charge is dumped from the pan and the operation repeated. The apparatus consists essentially of the furnace in which the charge is sintered; an exhauster which creates a blast of air downward through the charge; a mixer; a charge-car; and an igniter. The mixer, the charge-car, and the igniter, may serve from one to ten or more sintering-pans. Mixing is an important preliminary step to sintering. A properly mixed and proportioned charge sinters readily and the resulting sinter is usually in large chunks. A poorly mixed, or poorly proportioned, charge is likely to give inferior results, in which a considerable portion of the charge has to be returned for re-sintering. The charge should have about 10% moisture. The mixing may be done in a rotary drum like a concrete-mixer, in a rotary cylinder, or in a pug-mill. With thorough mixing, the charge becomes uniform in moisture and the combustible content is evenly distributed through the charge. The combustible content of the charge is important. It is impossible to get a good sinter from a concentrated sulphide material, or from iron-ore fine, containing an excessive amount of coke. The sulphur content in sintering lead or copper ores may vary from 5% to 15% sulphur. In sintering iron-ore flue-dust or magnetic concentrate the coke content may vary from 3% to 10% carbon. A good sinter may be made on some charges with as little as 2% carbon. Ordinarily, from 4% to 6% carbon, in the sintering of iron-ore flue-dust, will give the best results. In the sintering of copper-ore fine or flue-dust, from 5% to 10% sulphur will give uniformly good results. In sintering iron-ore fine, low in sulphur, the sulphur can be removed almost entirely. On the other hand, when it is desired to retain a high percentage of sulphur in the sinter, as in sintering copper-ore fine for the blast-furnace, this may be done by stopping the operation after the material has been sintered and before the sulphur is all removed. In cases where the material to be sintered contains too much combustible, such as coke or sulphur, the best method to adjust it is to dilute it with other fine material desired in the blast-furnace charge, such as any fine having a low combustible content. In sintering copper-sulphide concentrate the sulphur content can usually be adjusted to the desired amount by mixing flue-dust or fine crude ore with the sinter charge. In cases where such mixtures cannot well be made, as in galena concentrate, the material may be pre-roasted to bring the sulphur down to about 12% or 15%. Pre-roasted material sinters readily. The moisture in the charge, to get the best results in sintering, may vary somewhat with different material, but 10% moisture will be found a fair average.

The sintering pan consists, essentially, of a pan-shaped sintering-furnace, mounted on hollow trunnions, and divided into an upper and a lower portion by the grates. The upper portion receives the charge for sintering, and the lower portion communicates, through the hollow trunnions, with the exhauster, which creates a suction in the lower portion, or chamber, and causes a flow of air downward through the charge and through the hollow trunnions and exhauster into the stack. The grates are secured to the pan and interlocked. They are easily inserted and easily removed. The pans are made in various sizes. The usual sizes are: 6 by 8 ft., 8 by 12 ft., 9 by 16 ft., and 10 by 24 ft. The depth of the charge is the same for all the pans, and varies from 8 to 10 or more inches, depending on the material to be sintered. The 6 ft. by 8 ft. pan represents the smallest commercial unit and has a capacity, under ordinary conditions, of about one ton of sinter per charge. The 10 ft. by 24 ft. pan is the unit for the larger installations, and has a capacity of from 150 to 250 tons per day of 24 hours. These larger pans are arranged to dump directly into standard railroad cars. A sintering plant usually contains from one to ten or more pans. The pans are made of cast-steel and are practically indestructible. They are rotated on hollow trunnions by means of a special mechanism. When the sintering is completed the pans are rotated to dump the sinter and rotated back into position for a new charge. The small pans may be dumped without any special rotating mechanism. Connection is made with the exhauster by means of a stuffing-box at the ends of the hollow trunnions.

The exhauster is usually of the regular fan type. It is rotated at a high speed and has to be well made and the exhaust-wheel well balanced. A suction of from 30 to 35 in. of water is easily obtainable in the pans by this means. This is due largely to the fact that in the stationary charge there is no leakage and all the air and gases have to pass through the charge to get at the chamber below and through the hollow trunnions to the exhauster. There is an advantage in using a high suction. The sintering is more uniform, there is less unsintered fine, and the sinter is firmer and in larger chunks. In sintering iron-ore flue-dust, if the coke content is a little high, water is sometimes showered on the charge to cool it during the sintering. The temperature on such occasions may rise so high as to liquefy portions of the charge. The best way, however, to avoid this condition, is to work with a lower combustible content. It is, of course, desirable to sinter a charge at as high a temperature as practicable to get a firm sinter and as large chunks as possible, for the reason that the firm hard chunks add considerably to the desirability of the sinter in the operation of the blast-furnace.

The charge-car receives the mixed material and delivers it to the pan. In charging the pan, the car spreads a porous bed, or layer, of non-sinterable material over the grates, delivers the charge on top of the permeable layer, and levels the charge even with the top rim of the pan. This is all done in a few seconds, while the car travels with moderate speed over the pan. The charge-car is usually motor-driven, but may be

moved in any other convenient way. In small units the pans may be charged with hand-labour by simply spreading a permeable layer over the grates and shovelling in the charge and levelling it. This adds somewhat to the cost of sintering, but saves a little in the cost of installation. It may also do as a temporary expedient. The porous bed, or permeable layer of non-sinterable material, which usually varies from ½ to ¾ in. thick, serves several important purposes: it prevents the fine material of the charge from passing through the grate; it serves to distribute uniformly the air passing through the charge; and it prevents the charge from being sintered to the grates. If the charge were placed directly on the grates and the sintering completed, the charge would be sintered to the grates and the removal of the sinter would be difficult and expensive; besides the grates would be quickly destroyed. This porous bed acts as a buffer between the grates and the charge, so that when the pans are inverted the entire charge drops out and leaves the grate clean. The porous bed may be any comparatively non-sinterable material, such as fine sinter, crushed limestone, or crushed silicious or oxidized ore.

The ignition is one of the most important steps in sintering. Unless the ignition is uniform, the sintering will be uneven and some of the charge will remain unsintered. If the ignition is uniform the sinter will always be good on a suitable charge, and little fine will have to be returned. Manifestly, the quick and uniform ignition of the entire surface of the charge presented something of a problem, especially in connection with the 10 ft. by 24 ft. pans. This problem was thoroughly solved by the ignition-hood, or igniter, which temporarily covers the charge while the ignition-fuel is projected over the entire surface of the charge. The air for the combustion is sucked through the numerous perforations in the hood. The ignition-fuel may be oil or gas. Both are being used successfully. Crude oil is satisfactory. Distillate, or kerosene, is a good ignition-fuel if cheaply obtainable. Gas is usually cheaper than oil. Either natural gas, blast-furnace gas, or producer-gas may be used and are giving excellent results. The combustion should be complete. A sooty flame is not as good as a flame which does not show any unconsumed carbon. The oil or gas is so finely atomized and so intimately mixed with the inrushing air through the perforations in the hood that there is little or no difficulty in getting a clear flame. When the combustion is complete the temperature in the igniter is intense. The ignition can usually be made in a minute. The igniter itself does not become very hot; this is due to the cool inrushing air and to the momentary time required for ignition. In the operation of a commercial plant the igniter is mounted on wheels and runs on the same tracks as the charge-car. The hood, or igniter, is normally about half an inch above the upper rim of the pan, so that it can be freely moved over all the pans. When ignition is to be made the hood is temporarily lowered, and makes a close connection with the pan, so as to give a uniform ignition over the entire surface of the charge, and especially around the edges. If it were not for this, the inrushing air around the perimeter of the pan would divert the flame, and result in incomplete ignition. When the ignition is made, the hood is raised, and the igniter is ready for another pan. After the ignition has been made, the sintering of the charge proceeds without the igniter. The igniter is usually motor-driven, the same as the charge-car. For the smaller pans the igniter may simply be pushed from one pan to the other. If oil is used for ignition, it will usually take from 0·75 to 1·0 gallon per ton of sinter. In a small plant, in Mexico, sintering copper concentrate and flue-dust, the oil consumption was materially reduced by sprinkling a little waste coke or charcoal dust over the top of the charge. It was found, in this connection, that, if fine coke or charcoal were mixed with the sinter charge of copper concentrate and flue-dust, much of the carbon would remain unconsumed and fixed in the sinter so as to make it available in the blast-furnace.

The sintering of a charge may be briefly described as follows: The mixed material, as also the porous bed, is delivered to the charge-car; the car is then run over the pan, and in passing over it the porous bedding is uniformly spread over the grates by the distributor at the front of the car, and the charge immediately placed upon the bedding and levelled off with the top rim of the pan. This usually takes less than a minute, even for the 10 ft. by 24 ft. pans. The exhauster is then started, or switched on to the pan. This creates a strong downward draft of air through the charge. The igniter is then run over the pan and the ignition-fuel, under a high pressure, is atomized over the charge and ignited. The flame and hot products of combustion are sucked down through the charge and completely ignite the surface, usually in less than a minute. The igniter may then be removed and used for another charge. The time of sintering may vary from 15 to 60 minutes, depending on the nature of the material and the results desired. The suction may vary from 10 to 35 in. of water. It is usually higher at the beginning than at the end of the operation, for the reason that at the beginning the mass is not as permeable. With a high suction, there is not so much danger of short circuits of the air through the charge; when a short circuit occurs, the temperature at that point becomes so intense as to cause fusion, which automatically has a tendency to close the larger air-passages through the partly sintered charge, and make the sintering more intense at other portions. When the sintering is complete, the exhaust is shut off, the pan mechanically rotated, and the sinter dumped. The pan is then rotated back to its normal position, and the cycle repeated. In some of the large plants the cycle is completed in about 20 minutes

The power required for sintering depends somewhat on the nature of the material to be sintered. Ordinarily, it will be from 5 to 6·5 kw.-hr. per ton of sinter. The repairs are small and consist principally of the replacement of grates.

Several interesting problems arise in reference to sintering by the present method. One is the possibility of sintering concentrate for shipping instead of drying. Sintering requires about 10% moisture. Drying of the concentrate, if sintering is contemplated, would therefore be unnecessary and could be eliminated. Concentrates contain their own fuel for sintering, as opposed to extraneous fuel which has to be purchased for drying. The sinter would be ready for smelting, and the shipping weight would be reduced to from 15% to 20% from the ordinary dry-shipping weight. This reduction in weight is due to the replacement of the sulphur with the lighter oxygen, to the elimination of the water of hydration, to the elimination of other volatile elements, and to the evaporation of the uncombined moisture, which in ordinary drying is never complete. A reduction of from 15% to 20% in the shipping and smelting weight will ordinarily much more than pay for the sintering. If the sulphur content in the concentrate is too high for sintering, the charge can often be diluted with fine shipping ore low in sulphur, and this would tend to give a greater porosity to the sinter charge, especially in the sintering process as applied to the treatment of flotation concentrate.

ELECTROSTATIC DEPOSITION OF POTASH-BEARING DUST.

At a meeting of the Cleveland Institution of Engineers held at Middlesbrough on February 7, E. Bury, A. Bury, O. Ollander, and F. Bainbridge presented a paper on the electrostatic precipitation of dust from blast-furnace gases and the extraction of potash therefrom. In our issues of February and March, 1918, we quoted a paper and a discussion on it relating to this subject read before the same society. The present paper gives further information in the light of subsequent experience. The paper contains two themes, one the electrostatic precipitation of dust, and the other the extraction of potash in the form of soluble salts. We quote the first part of the paper fully, because it reviews the subject generally. Hitherto most of the literature on the subject has come from the United States, and consequently many people think that the idea originated with Dr. Cottrell. The present paper puts the matter in a more correct light historically. The second part of the paper contains much information of use to those who are engaged in separating mixed salts.

Precipitation of Dust.—The formation of dust and fume in the iron blast-furnace takes place in four ways: (1) Dust carried in with the burden, namely, coke, ironstone, and limestone dust; (2) dust caused by attrition between the pieces of material as they descend the furnace; (3) dust caused by spalling-off of particles as the materials become heated; (4) fume, the result of volatilization of various chemical substances, particularly of chlorides, in the case of Yorkshire ores. The first three, while usually constituting by far the greater portion of the dust, are also the most easily removed, as their carriage is almost entirely dependent on the velocity of the gas stream. It has been stated by one writer on the subject that the quantity carried varies as the square of the velocity of the gas, and this seems reasonable for particles of a mechanical size. By "mechanical size" is meant particles large enough to obey mechanical laws, in contrast to particles so small that they may be compared to colloids, and will behave in a manner similar to a vapour or fume, in which case the law of the square of the velocity will not apply. Another writer quotes a statement that the dust carried varies as the seventh power of the velocity, but it seems difficult to believe such can be the case

There remains the fume, the smallest proportion of the total dust in the gas, the most difficult to remove, and usually the most valuable when recovered. It is formed low down in the furnace, and is due entirely to the heat volatilizing or subliming the various constituents, whose quantity depends entirely on that of the constituents contained in the burden. With regard to the water vapour, this will condense on a fall of temperature to below the dew-point, and consequent lowering of the gas velocity, and probably bring down a little of the chemical fume with it. The fume may be compared to the colloidal state of matter; that is, matter so finely divided that when mixed with a liquid it is beyond the laws of gravity, and refuses to settle out even after prolonged rest, unless some other influence is brought into action.

The authors have had the opportunity of inspecting two plants working under the Halberg-Beth system, and a very high efficiency has been reported. In one case the gas has been cleaned down to 0 007 gramme per cubic metre. The method employed is, after cooling below dew-point, to condense the water vapour, and then, raising the temperature to slightly above the dew-point to avoid any further deposition of moisture, to pass the gas through the filter-bags, where the dust is trapped. Apart from the loss of the sensible heat of the gas, the plant is elaborate mechanically, and occupies a larger ground space than the other methods.

With regard to the Kling-Weidlin system, the authors have had no experience of this, but have heard excellent reports. It consists of a mattress of steel fibres, through which the gas is passed, and is periodically shaken to remove the dust caught in it. It should be easy and inexpensive to install, it requires small space and little attention, and has the advantage of removing no sensible heat from the gas. The authors have seen a sample of the dust removed by this method, where it was installed on a plant using hematite ores. This dust was very different from that to which the authors are accustomed at Skinningrove, Yorkshire, being of a hard, gritty nature, with particles of a relatively large size. They are prepared to believe that, where dust of this character has to be dealt with, the Kling-Weidlin mattress will be highly efficient. They are afraid, however, that where fume exists in the dust to more than a minute extent the mattress will be clogged very rapidly, and no amount of shaking will dislodge it. Deposited fume such as exists at Skinningrove is a most difficult material to dislodge, even when hanging on a perpendicular surface, and the problem has not yet been solved to the authors' entire satisfaction.

Coming now to the electrostatic method of deposition, Sir Oliver Lodge about 1880 patented a method of depositing smoke for making lamp-black, and in later years considerable attention was drawn to his suggestion for the dispersal of fogs—which consist of water vapour and smoke intimately mixed—by means of an electric discharge, such as is given by a Leyden jar or Wimshurst machine. In recent years this method was employed on a practical scale by both Lodge in England and Cottrell in America for condensing SO_3 fumes in sulphuric acid concentrating plants. The latter also applied it to the recovery of dust from blast-furnaces employed in reducing copper ores. Both employ identically the same principle, the main differences between the two systems being in the manner in which the electrostatic discharge is generated and then applied to the gas stream. In the case of the Lodge system the discharge is generated by means of a static transformer of the induction-coil type, selective devices being employed for rectifying the discharge, so that it is uni-directional. Only a portion of the discharge is employed, namely, the "peak of the break," that is, the most intense portion. The apparatus employed is very light in character, and for the quantity of gas treated at Skinningrove a large number of such units are required, 32, or two to each chamber. So that it may be said that one of the features of this system is that practically standard units are employed, the number varying with the type and quantity of gas to be treated. The Cottrell system, on the other hand, employs much more massive plant for generating the discharge, consisting of a rotary transformer and rectifier, designed in accordance with the whole requirements of the plant, and only divided into units for purposes of stand-by, etc.

As regards the discharge electrodes in the gas stream, the Lodge system at Skinningrove employs an arrangement of vertical steel plates about 18 in. wide and 10 ft. long, placed edgewise to the flow of the gas in staggered rows, and standing on a grid of light sections, which are earthed. They are built to form a unit of 85 plates. Suspended between them from insulators in the roof of the treater chamber are vertical steel tubes, provided with discharge points on either side of

one diameter, and pointing to the steel receiving electrodes immediately opposite, on which the dust is deposited. Such a unit of electrodes is served by one of the discharge generating units already described, and two of them are installed in each chamber. The dust is removed by cutting off the gas flow, and striking the grids supporting the plates from below with hammers, and in the case of the discharge tubes by striking the frame from which they are suspended.

In the Cottrell system, vertical cast-iron pipes about 11 in. in diameter are employed, arranged in batteries and set into a header at their tops, which communicates with the dirty gas main, their lower ends standing on grids carried over the hopper in which the dust is deposited, with a side exit opening into the clean gas main. Hanging down the centre of each pipe is the discharge electrode, a chain sometimes being employed. The discharge passes from this electrode to the wall of the pipe, the dust being removed by mechanically-operated hammers striking the outside of the pipe, and by a shaking arrangement for the discharge electrodes. It is obvious that such an arrangement must occupy a much larger space for a given quantity of gas if the velocity is to be the same as the Lodge system. The authors have been informed, however, that the Cottrell operates at a velocity of 5 to 6 ft. per second, as against the Lodge at Skinningrove at 3 ft. per second. The Cottrell, however, employs considerably more power than the latter.

These are the main differences between the two systems. In both systems it is essential to high efficiency not only that the discharging electrodes should be all symmetrically disposed with regard to the receiving electrodes (plates or pipes), but that the gas should pass through them in an even, steady stream, with neither concentrations nor idle pockets. Should such conditions occur, dust will pile up unevenly on the discharge electrodes, so providing shorter paths for the discharge in which it will naturally concentrate, the result being that other electrodes will be robbed of discharge, no dust will be deposited thereon, and a free passage will be given to dirty gas.

The plant at Skinningrove consists of 16 chambers in parallel through which the gas is passed, each chamber containing two of the units of electrodes aforesaid, in tandem. Any chamber can be isolated for inspection, repair, etc. The plant is constructed of ferro concrete, and although some cracking of the chambers and gas mains has occurred, it has not happened to any serious extent, and in future structures could be largely avoided by a better disposition of the steel reinforcement, to take the bulging stresses set up under the influence of heat. The 32 discharge generators are stationed in the top floor, which rests on sliding shoes to allow for expansion, on the chambers proper. The space between the top floors and the roof of the chambers is occupied by the leads from the generators to the insulators from which the discharge electrodes are suspended, the arrangement ensuring a very short and sheltered path for the discharge from the generators to the chamber, thereby reducing leakage to a minimum. The chambers themselves, also resting on sliding shoes, are carried by the bridge over the slag tunnel.

Extraction of Potash.—The soluble constituents of the flue dust obtained from the electrostatic plant at Skinningrove Ironworks are almost entirely in the form of chlorides, only very minute traces of sulphate being present and carbonate and cyanide not at all. The average analysis is as follows: Soluble potassium chloride, 20%; soluble sodium chloride, 8%; soluble calcium chloride, 7%. On this account the separation of pure potassium chloride presented few difficulties. The method of separation finally decided upon is divided into two stages: (1) Separation of the sodium and potassium chloride from the calcium chloride as a mixed salt. (2) Separation of the potassium chloride from the sodium chloride. The first stage is accomplished by direct evaporation, and is rendered possible by reason of the extreme solubility of calcium chloride as compared with the solubility of sodium and potassium chloride, 31·7 kg. of calcium chloride requiring rather less than 49·1 kg. of water for solution. If, therefore, the strong liquor be evaporated to this concentration and cooled, 90% of the potassium chloride and sodium chloride will be thrown out of solution. It is possible further to reduce the KCl and NaCl content of the liquor, but as the calcium chloride may be used to remove the carbonate from alkali-carbonate-bearing flue dusts by double decomposition, there is no need to endanger the purity of the mixed crystals by further concentration.

The second separation is based on the fact that the solubility of potassium chloride increases with the temperature, while the solubility of the sodium chloride decreases, according to the following table of solubility in grammes per 100 grammes of water:

Deg. C.	KCl.	NaCl.
0	11·2	30·0
25	15·8	29·0
50	22·0	27·7
70	27·3	26·8
80	30·0	26·4
100	34·7	25·8

On evaporating the solution no crystals are deposited until a density of 46° Tw. is obtained, when the solution is saturated with potassium chloride. If evaporation be now continued, potassium chloride crystallizes out until a density of 49·5° Tw. is obtained. At this point, the solution is cooled and potassium chloride crystallizes out, finally reaching 25° C., which is the lowest temperature in actual practice. The solution is reheated to a point at which the solution is saturated with sodium chloride but not with potassium chloride. Evaporating further, sodium chloride will be deposited, and if the solution be filtered hot to remove the sodium chloride, potassium chloride again crystallizes out on cooling. The operations now become a cycle.

The dry dust from the conveyor is lixiviated with water or wash liquor as it falls from the conveyor chute into the concrete slurry tanks below the electrostatic plant. In order to prevent any settling this slurry is circulated continuously through the chute and agitated with blast, thus producing an intimate mixture, only enough water or liquor being added to produce a slurry thin enough to be pumped through the circulating system and to the mixers. In the mixers, which are steel vessels of about 800 gallons capacity, and provided with efficient stirring arrangements, the slurry is boiled and then continuously run down on to a series of revolving vacuum-filter drums situated below the mixer. The filter drums, which are 3 ft. 6 in. diameter, and 7 ft. 6 in. long, are built of oak laths 3 in. apart covered with a strong wire net, which carries the filter cloth. To protect the cloth an ⅛ in. steel wire is spirally wound round the drums, which are driven by a worm-gear and revolve at 3 to 4 revolutions per minute. The wells in which the drums revolve are built in concrete with a cast-iron front, and in order to prevent any settling they are made V-shaped, with a stirrer revolving along the bottom. The dried cake containing about 50% moisture is cut off by a steel knife placed in such a position that the cake flaked off from one drum falls into a repulping trough, and from there into the well of the next drum. In order to break the cake up into a thin slurry

this trough is fitted with a stirrer and an air lift, which continuously circulates the slurry from the drum well through the trough. All feed liquors for each drum are also fed into these troughs so as to get an intimate mixture. By having four drums, four consecutive washings with liquor of falling strength are obtained, the last washing being done with water; and the last cake, free from soluble salts, is transferred by a worm conveyor to railway trucks outside the building, whence it is returned to the blast-furnaces. The liquors from the four drums are drawn off by vacuum into separate tanks, and from there delivered intermittently to the respective storage tanks. The strongest liquor of about 30° Tw. from No. 1 drum is treated with air and lime if any soluble iron salts are present, and then filtered through a sand filter and delivered to the preliminary evaporator. The liquor from No. 2 drum goes to the slurry tanks, the liquor from No. 3 drum is used for washing in No. 2, that from No. 4 drum for washing in No. 3, and No. 4 receives water. The strong liquor of about 30° Tw. is transferred to a feed tank for the preliminary evaporator, and continuously fed into a Kestner salting-type evaporator, in which the separation of the sodium and potassium chloride from the calcium chloride takes place. The crystallization starts at about 62° Tw., and continues to about 94° Tw., when the liquor is approximately saturated with all three salts; above 76° Tw. the evaporation is very slow, and very little mixed salt is obtained. The liquor also becomes very viscous above this density and is difficult to filter. The evaporator is therefore emptied at this point and the solution allowed to cool, whereby a crop of crystals is obtained which contain approximately 10 to 15% calcium chloride, the remainder being a mixture of potassium chloride and sodium chloride. The mother-liquor drained from the above contains 90% of the total calcium chloride and only about 5% of the total potassium chloride in the original dust, and is further evaporated to dryness in open pans. After the mother-liquor is drained off, the crystals are dissolved in water or feed liquor for No. 1 evaporator, and returned to the feed tank for this evaporator. The crop of crystals received during the evaporation from 62° to 76° Tw. is from time to time emptied out of the separator of the evaporator on to a vacuum filter, the mother-liquor drawn off, and the remaining mixed salt washed twice with a hot saturated mixed salt solution in order to remove the calcium chloride, which generally amounts to 1 to 3% in the unwashed salt, the wash liquor being each time returned to the evaporator. The mixed crystals are dissolved in hot water in a tank. The resulting liquor of about 30° is filtered through a brick filter and passed on to the feed tank, from whence it is fed into the evaporator Evaporation is then commenced and continued until the liquor has a density of 49° Tw. During this evaporation potassium chloride crystallizes out, and more liquor is added until the evaporator is completely full of liquor of the required density, at which point the whole contents of the evaporator are run out and passed through a revolving crystallizer, more potassium chloride being deposited during the cooling. The mother-liquor is drained from the crystals in a centrifugal hydro-extractor and returned to the feed tank, from which it can either be supplied to the crystal dissolver, or to the evaporator for further evaporation. In the latter case the liquor is evaporated until the density again reaches 49° Tw., but owing to the saturation of the liquor only sodium chloride is thrown out of the solution during this second evaporation. The sodium chloride is removed from the evaporator by means of the vacuum filter box, and the clear liquor run through the crystallizer, when potassium chloride again crystallizes out. From this point the process is cyclic, sodium chloride crystallizing out on evaporation and potassium chloride on cooling. It is obvious, of course, that the above operations may be varied, and modifications are made from time to time in order that the final evaporator may be kept full of concentrated liquor. All crops of potassium chloride are washed twice with a cold saturated solution of potassium chloride in order to remove the last traces of mother-liquor, so as to produce a product containing at least 98% of potassium chloride.

Quicksilver Mining in China.—At a meeting of the Cornish Institute of Engineers held on February 19, Frank Trythall read a paper describing the mining of quicksilver in the Toon-Yen prefecture, Kwei-chow Province, South China. Quicksilver has been extensively mined in Kwei-chow, for how long no information can be obtained beyond the assertions of the landowners, who claim that their ancestors were mining for quicksilver during the Ming Dynasty (1368-1644). Gunpowder was introduced for the first time as an explosive about the year 1870 by miners from Sze-chuan. Previously fire-setting and the hammer and gad were the only means of mining. The geological formation of the region is magnesian limestone, in horizontally stratified beds of several hundred feet in thickness. The mineralized zone is roughly three miles square. The quicksilver deposits are not continuous, and they are irregular in shape. The country is cut by canyons running in various directions, and it is noticeable that those deposits which are near the rim of the canyons are richer and more extensively worked than those occurring farther afield. The ore occurs: (1) As impregnation of well-defined beds of limestone; (2) along the joints, cracks, and planes of stratification; (3) in isolated bunches, nests, or pockets, and in vughs or cavities which contain crystalline aggregates or well developed crystals of cinnabar in the form of penetration twins of two rhombohedra, associated with quartz and calcite; (4) irregularly disseminated through a number of beds which have, in most cases, undergone considerable local disturbances. There are two varieties of cinnabar. One is a bright, transparent red, the other a dark, opaque red with which antimony is almost invariably associated in small quantities. The former is known as the "red," and the latter as "black" cinnabar. Pyrites is entirely absent. Native mercury is occasionally met with, associated with the antimonial ores. These deposits are similar to, and characteristic of, others in the districts of Beh-mah-tung, Wuchuan, and Pachai.

The methods employed in mining and smelting are distinctly crude, and conform to no laws or regulations. About the time of the writer's visit, mining regulations were issued by the Imperial Government, but were never enforced, nor was the slightest notice taken of them. In the mines known as "private" mines, which have been acquired by a company, the miners are required to sharpen their own drills before entering the mine, and drill and fire two 15 in. holes. They drill single-handed with 7 lb. hammers, a back hole counting double. The drills, ⅞ in. diameter, are of iron, pointed with steel at both ends. Other mines, described as "public," are usually old workings which have been abandoned by companies as too poor to work, but still containing patches of sufficiently remunerative ore for individual miners, who are allowed to work them on payment of 600 cash (1s. 7d.) per month, known as "hammer tax," to the local magistrate. The miners work either on day's pay or on tribute. In the first case the hours worked amount at most to six; but every fifth

day, being market and pay day, is regarded as a holiday, when they receive 400 cash (about 1s.). In addition to the wages they are supplied daily with two meals, consisting of boiled rice and vegetables, and on market days a small portion of pork. The meals cost roughly 50 cash or 1·6 pence each. Thus a miner on day's pay earns, inclusive of his food, 130 cash (4·2 pence) per day, and works at the outside 24 hours in 5 days. Overtime is paid on all holes drilled above two in a shift at the rate of 1·2 pence per hole. The tributer supplies his own tools, explosives, etc., and works without restriction on a piece of ground allotted to him by a company, and his ore has to be taken to the company's smelter for treatment. He is paid for the quicksilver so produced at a rather lower rate than the prevailing market price, and, in addition, the buyer retains such mercury as remains in the furnace. All taxes are paid by the company to the officials and land-owners, whether the mines are worked on day's pay or tribute. In the blasting operations, after the hole has been drilled to the required depth, a pricker is inserted and from two to three ounces of gunpowder are tamped around it with an iron rod, after which the hole is filled with clay, or fines, nearly to the top. The pricker is then carefully withdrawn by twisting it with a pointed bar inserted in the eye of the pricker, and, in the space thus left, the fuse is introduced and a conical-shaped piece of paper attached to the end of the fuse, which, on being lit, smoulders and acts as a time fuse until it reaches the powder. The native fuse consists of a peculiar kind of brown paper, treated with nitre, and rolled very tightly, enclosing a minute quantity of gunpowder. When finished it has the appearance of a piece of whip cord. The timing is very unreliable. Owing to the inferior quality of the gunpowder (which is made on the mines from ingredients obtained locally), the explosive force is small, only from 200 to 300 lb. of rock being dislodged per hole drilled.

No system of driving, sinking, or stoping is observed in the winning of the ore, the miner simply following a stringer on a mineralized band of ore, enlarging or reducing his working face as the mineral widens or pinches, resulting in a series of intricate workings. Timbering is unnecessary, as the ground is compact and holds well, even in the largest workings. The ore is transported from the working face to the surface by means of baskets carrying 30 to 40 lb., fastened to the coolie's back by ropes which pass under the arms. In the very low and narrow workings where it is impossible to stand upright, wooden boxes containing the ore are drawn along the floor by small boys, crawling, with a rope passing around the neck, down the stomach, between the legs and attached to the box. On the ore reaching the surface, coolies, termed ore pickers, cob and pick it, as much as possible of the barren rock being discarded. The large crystals of cinnabar are detached by means of a stout pointed wire. The ore is crushed on a large flat stone with hammers, to pass a ⅛ in. bamboo sieve, and if the cinnabar is of the red variety, it is panned, the concentrates removed, and the tailings treated for quicksilver in the furnace retort. If the cinnabar is black, the panning is dispensed with, and the whole put direct into the furnace.

During the winter months, when agricultural labour is more or less at a standstill, a large percentage of the population turn their attention to the working over of the old dumps, and may be seen wending their way to the dumps at all hours of the morning, armed with a basket, hammer, and rake, and sometimes a lamp to enter the abandoned mines, returning in the evening with perhaps 10 to 15 lb. of picked ore containing 1% to 2% quicksilver. This ore is disposed of to the owners of private furnaces, of which there are a number scattered about the district. Pumping is a minor item, from the fact that the deposits are not deep-seated, and the deeply carved and fissured country does not permit of the accumulation of large quantities of water, which would prevent the natives from carrying out their primitive modes of mining. Where water accumulates in sufficient quantities to check operations, a bamboo or wooden chain-pump is installed, similar to those used for irrigation purposes, but if they prove inadequate, the workings affected are abandoned until the water recedes. Ventilation is also a question which does not worry the Chinese miner. The imperfect combustion of the explosive, the smoke arising from the oil lamps, the filthy habits of the miners themselves, and the fact that many absolutely live in the mine for fear of having their rich ore stolen, tend to make the air as foul as it is possible to conceive, and often, on entering a working, it is almost impossible to see how many are at work or what is being done. The miners will submit to all these discomforts and dangers to health rather than do any work which would cause expenditure without direct remuneration.

The furnaces, built in pairs, are 2 ft. 6 in. in diameter and 1 ft. 6 in. in height. Each consists of a cooking pan, which serves as a receptacle for the ore, resting on a round fire-place made of unburnt bricks, on which is placed a similar pan inverted, with a 12 in. hole in its centre. On this is built a collar of clay, 12 in. high, strengthened by a plaited bamboo network, extending a few inches above the clay collar, serving as a support to the upper pan. The top of the clay collar is grooved in the centre, and a third pan, with a 12 in. diameter hole, rests on its inner rim, and this, being covered by an earthenware pot which acts as a condenser, an annular space is formed between the groove, the lower part of the top pan, and the inner side of the bamboo network. Three holes ¾ in. diameter are pierced through the rim of clay on which the topmost pan rests, and are known as "percentage holes," inclining towards the centre of the furnace. The amount of quicksilver collected in this annular space depends on the inclination of the percentage holes, increasing in quantity as the angle of inclination increases. The earthenware pot or condenser is luted with fine residues and the bamboo network is lined with clay. Wood fuel is used for heating purposes. The usual charge for one furnace is 50 lb. of ore. The quicksilver vapours condense in the annular space and earthenware pot, which is changed at intervals until the ore is exhausted, when the residues are withdrawn by means of a shovel the blade of which is at right angles to its handle, and replaced by another charge. While the condenser is being changed, the ore in the pan is stirred with a wooden pole, the fumes escaping copiously during the operation. The condenser becomes coated with minutes globules of quicksilver, which on removal are run together by rubbing the surface with a rag forming a pool at the bottom of the pot. The losses, as far as can be estimated, vary between 30% and 40% of the total quicksilver. The amount collected in the condenser naturally depends on the richness of the ore treated, and sometimes as much as a catty (1·3 lb.) is collected. The metal is poured into bamboo flasks and eventually transported to the river ports in pigs' bladders. The residues, especially in the case of rich ores, which still contain imperfectly burnt ore, are ground by hand, sluiced, and the concentrates again retorted.

In addition to the furnaces at work near the mines, considerable numbers are owned by individuals who carry on custom smelting, receiving in payment the quicksilver collected in the annular space through the

percentage holes. The ore treated in these furnaces is obtained from the mines or from the dumps, and not infrequently by theft. The owners of private mines have a set of furnaces for rich ore, and another for poor ore, and, if the miner strikes a rich pocket, the ore is treated in the rich-ore furnaces, the percentage holes being so inclined that the furnace owner receives about 40% of the total distillate as his share. This is an established custom to which the miners willingly conform.

Bauxite in West Africa.—The report of Mr. A. E. Kitson, the Director of the Geological Survey of the Gold Coast, for the year 1919, just to hand, contains further information relating to the bauxite deposit at Mount Ejuanema discovered by him previously, and described in his report for 1917. The latter report was quoted in our issue for July, 1919, and we reproduce the more recent report herewith. It will be seen that some interesting notes are given, of value to those interested in the formation of bauxite.

The whole of the shafts at Mt. Ejuanema sunk through the bauxite deposits were carefully examined, the character of the bauxite noted, and numerous samples from top to bottom taken for analysis or record from nearly all the shafts. These shafts number 65 on the flat top of the mountain and 68 along the sides. The shafts on the top vary in depth from 19 ft. to 31 ft. to the bottom of the bauxite, or 23½ ft. to 33½ ft. in total depth. Those on the sides vary from 3½ ft. to 15½ ft. of rubbly and massive bauxite with soil, and in total depth from 4½ ft. to 33 ft. As disclosed by the shafts the average thickness of massive and rubbly bauxite, with interstitial finely granular bauxite, like red soil, is 20¼ ft. The massive bauxite is 12½ ft. thick, and the rubbly bauxite 7⅝ ft., but it is impossible at present to form more than a very approximate estimate of the proportion of red soil to the rest. Analyses of this material are in hand; those already received prove almost the whole of it to be bauxite. The surface soil, which is also probably very finely granular bauxite, has an average thickness of 2 ft. 10 in. It occurs only on certain parts of the top of the mountain, for massive bauxite outcrops cover considerable portions of it. The average of 17 analyses already made of bauxite from various portions of the deposit gives the following percentages: Al_2O_3, 60·55; Fe_2O_3, 9·75; TiO_2, 2·21; $CaO+MgO$, 0·73; SiO_2, 1·42; water, 25·59. The total quantity of bauxite on the mountain may be taken for the present at approximately 3,000,000 tons.

An interesting feature connected with the bauxite is that in many of the deeper shafts on the top of the mountain there was so much bad air caused by carbon dioxide that complete observations could not be made in all of them. In many cases the light of a lantern lowered into the shafts went out instantaneously on reaching depths varying from 5 to 15 ft. from the bottom of the shafts. Time did not permit repeated visits to these shafts, nor to exhaust the bad air by extemporized means, while no tornadoes supplied water when wanted to dissolve the gas. Consequently some 10 shafts have not been completely examined, for it was found that, even protected by a rope for rapid haulage, it was not safe to venture down owing to the bad effects of this gas. The source of the carbon dioxide is undetermined, but there is presumptive evidence that it is being exuded from the pores and cracks in the bauxite. It is certainly not due to decomposing vegetation fallen into the shafts, or to exhalations and exudations from the native workmen. Only some of the shafts, and those not the deepest, showed the presence of bad air. In one case a shaft being sunk was found the following morning to be so foul that the light vanished at once 10 ft. from the bottom. Many shafts, 20 to 30 ft. deep, with 6 to 18 in. of decaying vegetable matter, had no foul air, for no bad effects were felt at the bottom. Further, rats, mice, a squirrel, frogs, snakes, lizards, and insects of various kinds, which were found at the bottoms of many shafts, were quite lively, and even when burrowing into the material at the bottom seemed to suffer no ill effects. In other cases, usually in shafts without vegetable matter, they were somewhat torpid, possibly from starvation or injury. If carbon dioxide is now coming from the bauxite, there seems to be no reason to doubt that, dissolved in water, it is acting on the clay-shales and assisting in the formation of bauxite. Should this action be taking place, it is evident that bauxite is still in process of formation.

Flotation Applied to Coal.—Reference has been made in these columns on several occasions to the application of the Minerals Separation process to the flotation of coal and the means thereby secured for separating fine coal from the dusty or slimy material obtained from the screens or coal-washers respectively.

A paper on this subject was read by A. F. Bury and A. Bicknell before the Newcastle section of the Society of Chemical Industry on January 26. The authors said that the methods for separating impurities from coal had hitherto depended on the fact that coal was of less specific gravity than the waste, and the use of jig washers, tables, and other forms of gravity separators had been steadily perfected. All the machines developed for that purpose, however, had failed to treat in an efficient commercial manner the finer portions of the coal. Such a method had been evolved by the Minerals Separation, Ltd., whose froth-flotation processes had already created a revolution in the dressing of metallic ores. The experiments carried out by Minerals Separation, Ltd., showed that their flotation processes could be modified and adapted to the recovery of the large amount of coal daily going to waste in washery pit refuse, and to the reclaiming of the vast tonnage of coal thrown away in previous years. In 1919 it was suggested to the Skinningrove Iron Co. that the process thus developed might be employed advantageously for the purification of coal for the making of coke for blast-furnace use. Investigations showed beyond doubt that the process offered a means for the production of coal of very low ash, and subsequent coking tests showed how admirably the washed coal was suited to the production of the finest metallurgical coke.

Coal as delivered at the works might be briefly said to consist of a mixture of the following substances in varying proportions: (1) pure coal, having a low ash of from 2·5 to 5·0%; (2) bone coal, having a higher ash of from 10 to 16%; (3) shale containing a varying amount of bituminous matter and an ash of from 60 to 85%; (4) small quantities of other impurities such as gypsum and pyrites. The shale, gypsum, and pyrites could be removed by mechanical means providing the coal was crushed sufficiently fine to ensure that the shale was freed from coal, the degree of fineness varying with the extent to which the coal and shale were interstratified. The bone coal presented quite a different problem. Most Durham coking coals appeared to contain approximately 10% of the high-ash coal, in which the ash was so intimately mixed or even chemically combined that no separation was possible by mechanical means. It had been found that the ash of the bone coal could not be removed or reduced even when the coal was ground to pass a 200 mesh screen. The separation of the bone coal from the better qualities was one of the most striking features of the flotation process, and, it was believed, unattainable by any other method of coal purification.

Silver-Lead in Yukon. The *Canadian Mining Journal* for January 21 contains an article by W. E. Cockfield on silver-lead ore deposits in the Mayo district, Yukon Territory, some distance east of Klondyke. The press has contained news from time to time during the last few years of these discoveries, and brief references to them have been made in the publications of the Canadian Geological Survey. As attention has recently been attracted to them again, it is opportune to quote Mr. Cockfield's article.

In the year 1914, with the opening of the rich deposit at Galena creek, an impetus was given to the search for argentiferous galena, which resulted in the discovery of a number of promising properties. These include Keno Hill, Lookout Mountain, Rambler Hill, Stand-to Mountain, Mt. Cameron, and a number of others.

Keno ridge is a long wedge-shaped ridge lying between the heads of Lightning Creek, Christal Creek, and Ladue River about 42 miles from Mayo by road. It has the characteristic flat top of the Yukon plateau country, and is surmounted by a number of hillocks known locally as Keno Hill, Minto Hill, Monument Hill, Caribou Hill and Beauvette Hill. Upwards of 600 claims have been staked on the ridge, and on most of these sufficient work has been done to keep them in good standing. Real development work, however, has been performed only on a small number of groups. The geology of Keno Hill is similar to that of the greater part of Mayo area. The rocks exposed consist of a series of crystalline schists and gneisses, intruded by sills of greenstone and dykes and sills of rhyolite, quartz-porphyry, and granite-porphyry. The schist series is made up of gneissoid quartzite, quartz-mica schists, mica, and chlorite schists. The greenstone sills vary in colour, composition and texture, ranging from a diorite to a diabase. The acid sills and dykes are believed to be apophyses from a granite mass to the eastward. The strata in general have an east-west trend and dip to the south at low angles. Near the hillocks known as Keno Hill, Minto Hill, and Monument Hill, however, they undergo a sharp flexure, bending nearly at right angles, and in the vicinity of this flexure there is much local faulting. The ore-bodies are found in fissure veins and are consequently intimately related to the systems of faulting. Two such systems have been recognized, one of which is in a general way parallel to the trend of the strata and is referred to as longitudinal faulting; the other making an angle of 70° to 80° with these and cross-cutting the strata, is referred to as transverse faulting. In the longitudinal system one main fault traverses the ridge for several miles and in the vicinity of the flexure diverges into three main branches, which are also quite persistent. Traces of other faults parallel to these have been found, but owing to the rather heavy drift cover, they could not be followed any considerable distance. These faults are mineralized with quartz and arsenopyrite, and occasionally with galena, manganite, and siderite. The transverse faults occur in great numbers, particularly in the vicinity of the flexure. As a rule they are much shorter than the longitudinal faults and of relatively slight displacement. They are mineralized with galena, manganite, and siderite, and occasionally with calcite and blende. In both systems the galena is enriched in places with freibergite. The principal ore-shoots already discovered lie in the transverse faults. From what has already been learned it may be established as a general rule that where one of these fissures taps a longitudinal fault and passes upward out of a hard stratum such as quartzite or greenstone into schist, an ore-shoot will be found in the vein below the schist capping. In the longitudinal faults ore deposition has taken place at points where the older filling of quartz-arsenopyrite has been opened by a distinct fracture, but at some localities a disseminated ore occurs, which may have been introduced at the time of formation of these veins. The ore-shoots vary in width from a few inches up to 4 or 5 ft. The galena in them is fairly free from mixture with gangue minerals and samples are usually taken of the galena only. A content of about 200 ounces of silver per ton and 60% lead probably represents closely the value of the ore-shoots. None of these shoots has been fully blocked out as yet, and none of the deposits has been tested in depth. The galena occurs fresh and unaltered right at the surface, but on some properties carbonates are encountered at a depth of a few feet. In other cases no alteration was noted. It is expected that about 3,000 tons of ore will be hauled to Stewart river during the winter from these deposits. The Stewart discharges into the Yukon river 50 miles above Dawson City.

SHORT NOTICES.

Measuring Compressed Air.—At the meeting of the Midland Institute of Mining, Civil, and Mechanical Engineers held on January 22, J. L. Hodgson presented a paper on the metering of compressed air.

Mechanical Loading of Ships.—At the meeting of the Institution of Mechanical Engineers held on January 21, H. J. Smith read a paper on the mechanical loading of ships, giving much attention to the handling of minerals in bulk.

Working of Petroleum by Shafts and Galleries.—At the February meeting of the Institution of Petroleum Technologists, a paper was presented by Paul de Chambrier, describing the exploitation of oil deposits at Pechelbronn, Alsace, by means of shafts and galleries. This paper is an abstract of a pamphlet noticed in another column. By means of shafts and galleries the oil drains downward.

Flotation of Coal. — The *Iron and Coal Trades Review* for February 11 describes the application of the Minerals Separation flotation process to the recovery of fine coal from waste.

De-aeration of Solutions.—The December *Journal* of the Chemical, Metallurgical, and Mining Society of South Africa contains a paper by H. A. White discussing methods of removing oxygen from solutions and water by the addition of chemicals and giving details of his experiments with tannin, ferrous ammonium sulphate, manganese sulphate, etc. The suitability of chemicals for this purpose depends upon price, insolubility after oxygen absorption, and freedom from undesired reactions.

Estimation of Mercury.—At the February meeting of the Newcastle section of the Society of Chemical Industry, A. A. Hall described a quick method for the estimation of mercury.

Knudsen Furnace.—In the *Engineering and Mining Journal* for February 12, E. H. Robie describes the use of the Knudsen furnace in the pyritic smelting of Sudbury nickel-copper ores, and the experiments undertaken by the International Nickel Company.

Zirconia.—At the February meeting of the Birmingham section of the Society of Chemical Industry, E. C. Rossiter and P. H. Sanders read a paper on the preparation of zirconia from Brazilian ores, giving also a new method of determination.

Fume Precipitation.—*Engineering* for January 28 describes the Cottrell electrostatic plant as applied to the precipitation of SO_3 fume at the sulphuric acid plant of the Holton Heath cordite factory.

Electric Smelting.—In *Chemical and Metallurgical Engineering* for January 19, Jonas Herlenius writes on the electric furnace used in Sweden for producing pig iron.

Helium.—The *Journal* of the Franklin Institute for February contains a paper by R. B. Moore, chief chemist of the United States Bureau of Mines, on the history, properties, and commercial development of helium.

Mineral Matter in Coal.—At the meeting of the Midland Institute of Mining, Civil, and Mechanical Engineers held on January 22, Dr. R. Lessing presented a paper on the distribution and nature of mineral matter in coal. This is a paper of great importance.

Westmorland Minerals.—At a meeting of the Manchester Geological and Mining Society held last month, Vincent Bramall read a paper on the minerals found in the neighbourhood of Appleby, Westmorland, with special reference to barytes.

Canadian Gold and Silver.—At the meeting of the Royal Statistical Society held on February 15, J. Bonar read a paper entitled: The Mint and the Precious Metals in Canada.

Yampi Sound Iron Ores.—The *Queensland Government Mining Journal* for December contains an abstract of a report on the Yampi Sound iron ore deposits, northern West Australia, made for the Queensland Mines Department by C. F. V. Jackson and E. A. Cullen.

Salt Manufacture.—In *Chemical and Metallurgical Engineering* for February 2, W. L. Badger describes the salt deposits of Michigan and the method of raising the brine and manufacturing salt.

Non-Metallic Minerals in the United States.—In the *Engineering and Mining Journal* for January 29, R. B. Ladoo gives an account of the production of non-metallic minerals in the United States.

Fluor-Spar. — In the *Engineering and Mining Journal* for January 29, J. M. Blayney describes the mining of fluor-spar at Fairview, Illinois.

East Indian Topography. — The *Geographical Journal* for February contains a paper by G. A. F. Molengraaf on modern deep-sea research in the East Indian Archipelago. The paper contains much matter useful to the geologist interested in Eastern tin deposits.

Hydro-Electric Power in Wales.—In the *Engineer* for February 25, J. B. C. Kershaw gives an illustrated account of the hydro-electric installations in North Wales, in being and contemplated.

RECENT PATENTS PUBLISHED.

☞ *A copy of the specification of any of the patents mentioned in this column can be obtained by sending 1s. to the Patent Office, Southampton Buildings, Chancery Lane, London, W C 2., with a note of the number and year of the patent.*

16,719 of 1919 (157,487). H. S. POTTER, Johannesburg. A hammer drill with a reversible hammer piston and rotating device modified accordingly.

18,038 and 19,797 of 1919 (157,490). W. BROADBRIDGE, E. EDSER, and MINERALS SEPARATION, LTD., London. Agitation method for removing substances such as fats from emulsions.

18,498 of 1919 (158,010). JOHN THOMPSON, LTD., and H. E. PARTRIDGE, Wolverhampton. Method of coating iron and alloys of copper with aluminium.

21,188 of 1919 (156,852). W. L. MCLAUGHLIN, Decatur, Illinois. In grinding and pulverizing machines consisting of cylinders containing rods, the use of rods of varying diameters, whereby the interstitial spaces are reduced.

23,960 of 1919 (156,866). E. A. ASHCROFT, London. Treatment of complex sulphides with chlorine to make chlorides, and the treatment of these chlorides with magnesium or alloy of magnesium and lead or zinc for the production of metallic zinc and lead and magnesium chloride; the latter is electrolysed to recover the magnesium and chlorine.

24,767 of 1919 (157,523). C. M. CONDER and G. T. VIVIAN, Camborne. Improved vibrating screen.

24,936 of 1919 (133,716). DORR COMPANY, New York. In thickening tanks, arrangements whereby the solid settled materials are forced upward and discharged at a point near the top of the tanks.

25,544 of 1919 (157,554). P. A. MACKAY, London. Making lead sulphate pigment by treating galena with fuming sulphuric acid.

25,546 of 1919 (157,555). P. A. MACKAY, London. Recovering vanadium from vanadate of lead by treating with fuming sulphuric acid, thereby obtaining a soluble sulphate of vanadium and an insoluble compound of lead.

26,332 of 1919 (146,919). ARMOUR FERTILIZER WORKS, Chicago. Electric furnace for producing aluminium nitride.

26,542 of 1919 (156,944). T. L. GALLOWAY, Campbelltown, Scotland. Portable magnetometer, (described in the MAGAZINE for December).

26,570 of 1919 (157,576). S. HARE, Bishop Auckland. Improved method of mounting coal-cutters to enable them to work a wider track.

26,985 of 1919 (156,367). UNIVERSAL COAL MACHINE CO., Boston, U.S.A. Improved tunnel-boring machine.

28,091 of 1919 (135,199). C. L. STICKNEY, Skull Valley, Arizona. An expanding bit for use in rock-drills, having for its object the widening of the drill-hole at the bottom into a chamber to take the charge of powder.

29,417 of 1919 (156,971). Y. NISHIZAWA, Tokyo, Japan. The addition to white sulphide pigments of organic hydroxyl compounds, with the object of preventing the pigments turning yellow.

30,613 of 1919 (136,177). GEBRÜDER EICKHOFF, Bochum, Germany. Improved compressed-air motors for jigging conveyors.

30,930 of 1919 (156,396). W. W. HOOVER and T. E. BROWN, New York. Distilling oil from shale in situ, by fracturing the shale by explosives and circulating a heating medium through it.

31,661 of 1919 (136,831). SOCIETA MILANESE IMPIANTI INDUSTRIALI CORTESE-CRESPI-SQUASSI, Milan, Italy. A rotary pulverizer for minerals.

1,267 of 1920 (156,414). TAYLOR-WHARTON IRON AND STEEL CO., Highbridge, New Jersey. Improved teeth for the edges of excavator buckets.

5,192 of 1920 (158,154). S. O. COWPER-COLES, London. Improvements in drums used in the sherardizing process.

5,227 of 1920 (139,219). J. E. KENNEDY, New York. Improved mounting for the shafts of gyratory crushers.

15,775 of 1920 (144,710). GRAF SCHWERIN AKTIEN GESELLSCHAFT, Berlin. Improved method of separating substances by electro-osmosis.

16,521 of 1920 (147,546). FRIED. KRUPP AKTIEN GESELLSCHAFT GRUSONWERK, Magdeburg, Germany. Improvements in magnetic separators.

16,533 of 1920 (145,444). L. MALECOT, Grand Croix, Loire, France. Classifier for coal and other minerals.

33,450 of 1920 (156,475). H. S. POTTER, Johannesburg. Improved rotatable chuck for steels of hammer-drills.

NEW BOOKS, PAMPHLETS, Etc.

☛ Copies of the books, etc., mentioned below can be obtained through the Technical Bookshop of *The Mining Magazine*, 723, Salisbury House, London Wall, E.C.2.

Quin's Metal Handbook and Statistics, 1921. Compiled by L. H. QUIN. Price 5s. net. Published by the Metal Information Bureau, Ltd., 7, East India Avenue, London, E.C.3. This is the eighth yearly issue of a statistical publication which is invaluable to all interested in the output and sale of metals and minerals. The advertisements form a useful feature of the book, for they convey a good deal of information with regard to the marketing of metals and the metal trade, and will be continuously helpful to the producer and buyer.

The Mining Manual and Mining Year-book, 1921. By WALTER R. SKINNER. Price 20s. net. Published by W. R. Skinner, 11 and 12, Clement's Lane, and *The Financial Times*, 72, Coleman Street, London. This is the 35th annual volume of the standard reference book relating to mining companies registered in this country and companies registered abroad that are known among English investors.

Cobalt, 1913 to 1919. Pamphlet published by the Imperial Mineral Resources Bureau. Price 9d.

Antimony, 1913 to 1919. Pamphlet published by the Imperial Mineral Resources Bureau. Price 1s.

Mining and Preparing Domestic Graphite for Crucible Use. By G. D. DUB and F. G. MOSES. Bulletin 112 of the United States Bureau of Mines.

Bolivia's Case for the League of Nations. By JOSE CARRASCO. Published by Selwyn & Blount, 21, York Buildings, Adelphi, London, W.C.2.

Manufacture of Sulphuric Acid in the United States. By A. E. WELLS and D. E. FOGG. Bulletin 184 of the United States Bureau of Mines.

Crystallography ; A series of Nets for the Construction of Models Illustrative of Simple Crystalline Forms. By JAMES B. JORDAN. Price 3s. London: Thomas Murby & Co.

Exploitation du Pétrole par Puits et Galeries. By PAUL DE CHAMBRIER. Paris: Dunod, 47 and 49, Quai des Grands-Augustins. A paper based on this pamphlet was read at the February meeting of the Institution of Petroleum Technologists.

Geothermal Data of the United States. By N. H. DARTON. Bulletin 701 of the United States Geological Survey. In this volume are collected all the available records of earth temperatures in the United States, together with many original investigations.

Refractory Materials : Fireclays, Resources and Geology. Paper covers, octavo, 250 pages, illustrated. Price 8s. net. This is vol. xiv. of the special reports on the mineral resources of Great Britain prepared by the Geological Survey. The volume contains a brief but comprehensive account of the geology of the fireclay deposits of Great Britain, with special reference to those beds which are at present employed for the manufacture of fire-bricks, furnace-linings, and other refractory materials. The industry is an old-established one, and, especially during the war, was of great national importance. The British fire-clays are described according to the counties in which they occur, and particulars are given of every deposit that is known to be of economic value. Fortunately for the country there is an abundant supply of fire-clay, and the reserves are large, while the variety of clays is such that almost every use to which the mineral is put can be adequately provided for from home sources. The volume is a sequel to the Memoir on Silicious Refractories previously published, and it is intended to issue another part containing chemical analyses and furnace-tests of many of the best known fire-clays.

COMPANY REPORTS

Taquah Central Mines.—This company was formed in 1909 to acquire gold-mining claims at Tarkwa, West Africa. Bewick, Moreing & Co. and the Taquah-Abosso group were interested. The property was being developed in 1912 when the workings were flooded. As recorded last June, the mines are being reopened, £60,000 of new capital having been subscribed. Bewick, Moreing & Co. have retired from the general managership, and the management has been transferred to the Taquah Mining & Exploration Company. The report now published covers the year ended June 30 last. This shows that work was resumed in July. The surface plant has been reorganized and additional plant supplied. The present development work consists of making connection between two adits 2,000 ft. apart. When the pumps are going, development will be undertaken on the 400 ft. level. The labour position in this district is improving.

Geevor Tin Mines.—The report of this company, which operates tin mines near St. Just, Cornwall, covers the year ended March 31, 1920. During this period 28,324 tons of ore was treated, yielding 432 tons of tin concentrate, being an average of 34·16 lb. per ton. The amount received by the sale of this concentrate was £69,064, or £159. 17s. 5d. per ton. After allowing for depreciation and writing off a proportion of development and shaft-sinking, the balance of profit was £6,256, which was carried forward. In our issue of December, 1919, details were given of the increase in capital for the purpose of extending operations; during the period covered by the present report £21,407 was spent on this extra development and £17,605 on additional equipment. Last summer further capital was issued for the purpose of acquiring control of Levant. The present position at Geevor is that mining is suspended owing to the low price of tin. Further particulars are given in the Review of Mining.

De Beers Consolidated.—This company has been working diamond mines near Kimberley, Cape Province, South Africa, since 1888. The report for the year ended June 30 last shows that 1,927,178 loads of diamond ground was raised at the Wesselton mine, 2,021,026 loads at Bultfontein, and 1,796,573 loads at Dutoitspan, making a total of 5,744,777 loads. The amounts of weathered ground washed at these mines were 1,646,895 loads, 2,251,895 loads, and 1,892,558 loads respectively, making a total of 5,790,710 loads. The respective yields per load were 0·24 carat, 0·29 carat, and 0·16 carat. As already recorded, disintegration by weathering is being abandoned for mechanical breaking, as adopted at the Premier diamond mine. The accounts show a mining expenditure of £1,991,258, and other expenditure £741,976. The credit for sales of diamonds was £6,761,840, and interest and dividends brought the total revenue to £6,997,899. The profit was £4,264,665, out of which £439,550 was paid as taxes, £800,000 was paid as preference dividend, and £3,000,000 as ordinary dividend, the rate on the preference shares being 40% and on the ordinary 120 per cent.

Exploration Company.—The report of this company for 1920 shows a gross profit of £74,599 and a net profit of £57,162; £20,000 has been written off for depreciation, and £37,500 has been distributed as dividend, being 10% tax paid. The low American exchange during the early part of 1920 made it profitable to sell nearly all the company's investments in the United States. At the meeting of shareholders, the chairman, R. T. Bayliss, spoke very hopefully of the prospects in Mexico and recorded his desire to increase the company's business in that country provided suitable properties came before his notice.

The Mining Magazine

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EDITORIAL

FUEL composed of a mixture of oil and coal dust is being tried in locomotives on the Great Central Railway with encouraging results. Experiments are now being conducted with a view to perfecting the burners and combustion chambers. The reports indicate that this type of fuel is easier to handle than coal dust.

IT will be remembered that recent efforts of the Institution of Civil Engineers to protect the term "civil engineer" failed owing to the difficulty of dealing with engineers who were not members of the Institution but were nevertheless of high professional standing. The Institution is now applying to the Privy Council for a supplementary charter to enable it to confer the title "chartered civil engineer," which shall be recognized as a mark of professional civil engineering status. Members of other societies will no doubt make the necessary inquiries so as to ascertain how this proposal will affect them.

THE removal of gases dissolved in water, especially oxygen, is nowadays receiving the close attention of chemists and other engineers. The Crowe vacuum treatment in cyaniding is one example of this line of research and improvement. Another example is found in the similar method of softening water for boilers and other chemical and mechanical applications. The removal of oxygen may be effected by heat, vacuum, or chemical reaction, and the relative advantages of the methods may be tested for each individual application. Readers interested in this subject should study a paper by Mr. Paul Kestner, presented to the Institution of Mechanical Engineers and the Society of Chemical Industry last month, and another paper by Mr. H. A. White, published in the December *Journal* of the Chemical, Metallurgical, & Mining Society of South Africa. Exigencies of space have prevented us from giving fuller notice of these papers.

LORD Moulton, who died last month, was in many ways a remarkable man, whether considered as a mathematician, scientist, administrator, or lawyer. Perhaps his greatest service to the country was done as head of the explosives department of the Ministry of Munitions, where, in conjunction with Mr. Kenneth Quinan, he impressed the true requirements of the country upon the military authorities and the politicians, and forced the expansion of production. He shone less as a lawyer than as a scientist, for the miserable insincerities of patent litigation have the tendency of narrowing a man's mental process. Science lost a powerful exponent when Moulton became an expert in patent law.

LELAND Stanford University is about to establish a research institute for the study of the problems of the production, distribution, and consumption of food, and it is proposed that the institute shall bear the name of Mr. H. C. Hoover, who has deposited with his alma mater an enormous amount of documentary material on these subjects, accumulated during his work in connection with the Belgian Relief Fund and also as Food Controller for the United States. A large measure of financial support for the institute will come from the Carnegie trustees.

THE destruction of marine life by oil discharged from ocean-going and other ships continues to receive the attention of various authorities around the coast. The Kent and Essex Sea Fisheries Committee, at a meeting held last month at Fishmongers' Hall, had much to say on this subject. It was stated that at times the surface of the lower reaches of the river and even the sea off Southend are covered with oil, which settles on the flats at low tide. The fishermen who used to make a good living between the Essex and Kent coasts are giving up their operations owing to the detrimental effect of oil on the young fish.

THE holiday course in economic geology held in connection with the Camborne School of Mines last summer was a great success, for students, young and old, were attracted from all parts of England. Preparations are now in hand for a similar course during the coming summer, the period to be occupied extending from July 18 to August 27. On two days every week there will be lectures and laboratory work dealing with rocks and rock-forming minerals, veinstones in the hand specimen and thin section, and mechanical analysis of alluvial sands and dressing products by vanning, magnetic, electrostatic, and flotation methods and by means of heavy liquids. One day a week will be devoted to the detailed mapping of a small area on surface and underground. On one day a week there will be a short local

excursion, and on another day every week a longer excursion, occupying the whole day. These longer excursions will be to St. Just and Land's End, and to St. Ives and Zennor, where contact metamorphism and mining methods will be studied; to St. Austell district, in order to visit china-clay properties; to Carnmenellis, south of Camborne, where granite is quarried; to the Porthleven district to study intrusions; and to the Lizard, to study Pre-Cambrian rocks. Those desirous of attending the course should communicate with Mr. E. H. Davison, lecturer on geology at Camborne School of Mines.

ANNUAL meetings of the Canadian Institute of Mining Engineers, now the Canadian Institute of Mining and Metallurgy, have a widely established reputation on account of the keen interest shown in the discussions and the good fellowship of the social sessions. The Montreal meeting of 1921, held from March 2 to 4 inclusive, was fully up to the past standards of the Institute. Notable papers were read dealing with the newly discovered petroleum fields of the Mackenzie River basin, the necessity for a more active development of the coal and iron industries of the Dominion, and other matters of national and imperial importance. Reference to some of these papers will be made in due course in the Mining Digest. At the dinner, General Sir Arthur Currie, the new head of McGill University, was among the speakers. He referred feelingly to the last previous meeting of the Institute that he had attended, a session organized behind the fighting lines in Flanders during the dark winter of 1916. Much has happened since then, and while perhaps not all the swords have been turned into ploughshares, it is a pleasure to record the general satisfaction felt at the conversion of this well known general into the Principal of McGill University.

The Mineral Resources Bureau.

Judging by the second annual report just issued, the Imperial Mineral Resources Bureau appears to have got into its stride. It enjoys the advantage of the assistance and advice of all the Governments of the Empire, of every technical and scientific society devoted directly or indirectly to the consideration of problems relating to metals and minerals, and of a great many of the big mining and manufacturing companies. The multitudinous consultative committees are composed of acknowledged experts on their own particular subjects. The list of Government representatives and representatives of societies, together with the list of members of individual committees, should give confidence in the work of the Bureau and its future. We would wish, however, to see the services of the permanent staff acknowledged in the report in greater detail. As it is, the only men giving all or a large share of their time to the service of the Bureau that are mentioned in the report are Sir Richard Redmayne, the Chairman of the Governors, and Major Henderson Scott, the general secretary. There are surely others who deserve public recognition.

As regards the publications issued by the Bureau, it is to be noted that the various reports commence with the year 1913, and the first issue of each series covers the years 1913 to 1919. Subsequently the issues will be made yearly. The subjects covered by the reports already published are: Arsenic, Bismuth, Felspar, Borates, Fuller's Earth, Magnesite, Chrome Ore and Chromium, Nitrates, Monazite, Asbestos, and Zinc. Reports on Cobalt and Aluminium may be expected any day, and others nearly ready for publication deal with Manganese, Copper, Coal, Lead, Phosphates, Fluorspar, Talc and Mica, Vanadium, and Barium. Those in course of preparation deal with Tungsten, Gold, Titanium, Platinum, Tin, Silver, and Nickel. The collection of statistics and records is always a difficult matter, even under the most favourable auspices, but the period 1913 to 1919 gives particular trouble owing to the incidence of the war. Hence the delay in publication and the incompleteness of some of the statistics. To give an idea of the range and scope of these reports, it is convenient to examine that on Zinc, the most recently published. This report was prepared by the staff of the Bureau and passed by Messrs. J. C. Moulden, H. M. Ridge, and H. Livingstone Sulman, the Bureau's technical committee on zinc. It consists of 112 pages. The first chapter deals with the ores and methods of extraction, the uses of zinc as a metal, in alloys, and in compounds. Then a general review is given of the world's production, with tables of yearly production of zinc and ores in each country. The countries are then taken seriatim, firstly the constituents in the British Empire and afterward foreign states. Full statistical information is given, and the principal producing centres are briefly outlined. Afterward comes a bibliography of books, articles, and papers on zinc, a truly valuable feature of the report. Finally there is a review of the metallurgical industry in connection with zinc as at the end of 1919, written by Mr. Gilbert Rigg, of the Broken Hill Associated Smelters.

The Bureau has in hand a special and comprehensive work on the Iron Ore Resources of the World, the preparation of which was undertaken at the suggestion of the National Federation of Iron and Steel Manufacturers. The sections devoted to Spain, Portugal, Norway, Sweden are under the general editorship of Professor Henry Louis. Mr. E. O. Forster Brown is supervising the sections dealing with France and North Africa, and Dr. F. H. Hatch the section on the ores of the United Kingdom.

As regards the future of the Bureau, it is legitimate to express a hope that the energies now displayed without adequate supervision by the Imperial Institute in the publication of general reviews of subjects connected with metals and minerals should not be continued independently of the Bureau. Before the Bureau was founded, some doubts existed in many quarters as to the advisability of the step being taken, the view being that the organization already existed at the Imperial Institute. Under the conditions now existing, such critics are inclined to advise the Imperial Institute to hand over this department of its work to the Bureau. Another point to which reference may be made is the establishment of records of commercial reports made on mining districts and individual properties. This MAGAZINE attempted to establish a register of this sort some years ago, but engineers generally felt that the enterprise should not be in the hands of a privately owned company. Such a register would be of great value to people contemplating the development of mineral deposits, and it is possible that the Bureau could undertake its formation. We make the suggestion for what it is worth.

Mining at Great Depths.

The discussion on Mr. E. H. Clifford's paper on the new shaft at City Deep, read in February before the Institution of Mining and Metallurgy, was continued at the March meeting, on which occasion Dr. Leonard Hill gave a helpful and illuminating address on various points connected with the physiological aspects of the problem. Indeed, the whole discussion at both meetings has turned on the consideration of this side of the question rather than on the mechanical features involved in the design of the shaft and plant. As mentioned last month, Dr. Leonard Hill is a physician who has made a special study of ventilation, heating, and cooling in relation to their influence on human comfort and capacity for work, and it was a happy thought on the part of the Council of the Institution to invite him to take part in the discussion. They have also invited him to write a paper for the Transactions, which will in all probability be read at the meeting in October. We can see in the future Dr. Hill giving valuable advice to the exploiters of deep metal mines, when the physiological factor becomes increasingly predominant.

One or two points in connection with the physiology of mining other than the reduction of heat and moisture were discussed at the meeting and deserve attention. In the first place Mr. Bernard Holman, of the Royal School of Mines, mentioned the ill effects caused by the absorption of nitrogen from the air into the blood while working under considerable air-pressure. This nitrogen is apt to be liberated from the blood with fatal effect if the pressure is reduced too rapidly, and thus there may be danger in bringing the men to the surface at the usual speed of a winding engine. This nitrogen danger is well known in diving operations, though the average man in the street is, of course, not aware of its existence. In the operations for the salving of the gold on board the Laurentic, which sunk in Lough Swilly during the war as a result of torpedo attack, the divers can reach the bottom at 20 fathoms in half a minute without discomfort, but fully half an hour must be allowed for bringing them to the surface again. The same precaution is necessary in connection with caisson work, where intermediate chambers are provided for gradually reducing the pressure so that the excess nitrogen shall be liberated without harmful effects to the worker. This question of relative absorption of the constituents of the air by liquids arises also in the system of compressing air by falling water, and transmitting to the point required for its use while absorbed in the water. When this method of compressing was adopted at mines in Canada ten years ago it was found that the air discharged from rock-drills would not support combustion of the lamps or candles and that this form of compressed air was therefore not ideal for the worker. It was discovered on examination that less of the dissolved oxygen was liberated than of the nitrogen, with the result that the released air was deficient in oxygen. Reverting once more to the effect of the compressed atmosphere in deep mines, it must be remembered that the surface of the Rand is 5,000 ft. above sea-level, so that at the bottom of City Deep shaft the workings will only be 2,000 ft. below the sea. Thus the air-pressure in the bottom workings will not be anything out of the way, and the nitrogen effect need not be considered. Dr. Hill, indeed, expressed his opinion that the

nitrogen effect will not arise at any depth to which a mine is likely to be sunk. Nevertheless depth in its relation to rapidity of hoisting cannot be eliminated entirely when considering these questions.

In the discussion, Dr. Hill also referred to the investigations at present being made into the causes of silicosis in the mines of the Rand. This disease of the lungs is attributed to the effect of minute sharp particles of silica, which settle on the surfaces in the lungs, and which cannot be removed in the ordinary course by the action of the lungs. The difficulty arising out of this interpretation is that the same effect is not noticed in other metal mines where quartz ores are worked. The present tentative explanation is that it is only when the quartz particles are unaccompanied by the dust of other minerals that silicosis starts; that is to say, the other minerals which are more easily removed carry the quartz spicules with them. Thus schists, shales, and igneous rocks of the wall-rocks at other mines act as preventatives of silicosis, but where foot and hanging walls are quartzite there is no constituent of the dust to counteract the effect of the silica of the ore. It has been suggested that a cure may be obtained by introducing shale or coal dust into the air of the Rand mines in order to render the silicious dust innocuous. It might also be possible to make use in some way of the rock of the diorite dykes for this purpose. The study of these phenomena is now in hand, and some definite results should be forthcoming before long. We are looking forward also with interest to Dr. Hill's paper to be read in October next. By that time he will have had the opportunity of applying his principles and methods to the particular problems of mining, and no doubt many valuable hints and suggestions will result.

Iron Ore and Greenstone.

During the last few months a number of articles and letters have appeared in our pages by Mr. J. D. Kendall and others, and in these communications much has been said relative to the origin of the iron ores of Cumberland and elsewhere. Mr. Kendall's evidence is helpful, for facts known many years ago, but not now available owing to the exhaustion of the particular mines, have been put on record, and interpreted in the light of modern theories of ore deposits. Geologists therefore have reason to thank Mr. Kendall for his articles. In the present issue Mr. J. H. Goodchild comes forward with a suggestion with regard to the origin of these iron ores which involves an entirely new conception with regard to the building of the earth. Mr. Goodchild's ideas call for a new method of examining geological and mineralogical occurrences, and a new interpretation of both the old and new facts. It is not easy to follow his statements and arguments. Like Einstein's theory, they are in the nature of an endeavour to grasp and enunciate some better explanation of various phenomena than has been available hitherto, and the resources of language wherewith to express the ideas are limited. They are as subversive of the current dogmas of the stratigraphist as these dogmas were of Genesis. Instead of expanding on his views from a general standpoint, we may raise the specific case of the greenstones occurring in association with hematite. It is usually supposed that greenstones are igneous rocks which have been extruded from below while molten. In years gone by the Cumberland hematite was also reckoned by many to be of igneous origin, but nowadays the solution theory is universally held. It usually happens in these occurrences that the contact between the greenstone and the country rock and hematite shows no sign of metamorphism, so the question arises whether the greenstone really had an igneous origin. This doubt once raised, it becomes necessary to re-apply from a different point of view the theory of Van Hise and Leith, according to which the Lake Superior hematites have been formed by the decomposition of iron silicates such as greenalite. Is it not feasible, asks Mr. Goodchild, that during this decomposition a concurrent formation of greenstone should take place? This question opens up a new line of thought, and should not be too hastily answered. To carry Mr. Goodchild's views a little further, it may be said that he questions the so-called igneous origin of many rocks, and that he doubts the separate creation of certain rocks and their enclosures, holding that in many cases both rock and enclosures have been formed at the same time. There are many other phases of rock and ore formation that might be discussed from the new point of view, but we leave readers to study Mr. Goodchild's letter. In his concluding paragraph he asks permission to return to this subject later. We give him not only permission but every encouragement to do so.

Adventures in the Desert.

The parched lands of Australia were never the ideal hunting ground for the prospector, and the records of travellers and explorers show an unbroken story of privation, thirst, or fire. Though the country is now better known, and improved means of communication exist, un-

toward events are still happening from time to time. It was hoped by many that the advent of the motor car would entirely eliminate the dangers, but motor cars occasionally go wrong, and misinformation and miscalculation may put even a Rolls-Royce out of action. We are reminded once more of the perils of the desert by the receipt of a letter from friends in West Australia, who have sent us an account of their terrible experience due both to scarcity of water and to bush fires. The writers of the letter, like average Englishmen, do not shout of their troubles from the house tops, so in recounting their experience we shall refer to them anonymously. Suffice it to say, then, that early in January a party, consisting of three engineers and the young son of one of them, left Perth for Ravensthorpe, a distance of nearly 300 miles in a south-easterly direction, travelling across the country by motor car. The journey out was successful, and after the business in hand was completed, the return trip was commenced. For the sake of variety they decided to travel by a newly-cut track, which was described as bumpy but safe. The road proved to consist for most of the way of heavy drift sand, and it was necessary to go at low gear. This had the effect of consuming much water in the radiator per mile, but as there are well-holes at intervals along the track the travellers were not worried. However, when the first well-hole, at 40 miles, was reached, it was found to be dry, but this fact caused little uneasiness, for it was expected that the remaining six gallons of water would be sufficient until the next well-hole, 40 miles further, was reached. After proceeding some miles from the first well-hole the catastrophe happened. In negotiating a bit of heavy sand, the car wheeled right on to a stump covered with bushes and a front axle went. There was no traffic on the road to furnish help, and the only thing to do was for the most active members of the party to tramp back the best part of fifty miles to borrow a spare axle and bring out a fresh supply of water, or to obtain some other form of relief. Two of the engineers undertook this journey, leaving the other engineer and the boy with the car. To tramp fifty miles through heavy sand with the temperature at 110° was no small undertaking. The position of the two left behind was not much better, for the short scrub afforded scanty shade, and there was only a gallon of water on which to subsist until relief arrived. But this was nothing to what followed. Before long smoke was smelt by the watchers at the car, and in an hour's time the clouds of smoke were thick. On walking to the nearest hillock they could see that the whole country was on fire, in a continuous blaze for miles. The smoke and heat gradually became more intense. The only resource was to seek the most open spot and to clear as much scrub as possible, then to trust to luck that the fire would pass round them and leave them still alive. The water-supply was severely rationed, the boy taking a table-spoonful every hour and the engineer one every two hours, though both of them felt like drinking the whole lot in one gulp. After several hours of this anxious waiting the wind changed, as it often does in Australia about sundown, and the further advance of the fire was stayed. The watchers were therefore able to lie down and sleep. In the meantime the other two engineers had plodded on their weary way, often only able to walk a quarter of a mile and then rest for a few minutes. This they did continuously for twenty-four hours, covering during this time 46 miles, mostly in heavy sand. Then they espied a farm-house in the distance, so they drank up their remaining water and lay down to sleep for an hour. On awaking they dragged themselves to the house, where they received food and drink, and help to cover the remaining distance into Ravensthorpe. Here no time was lost in obtaining a spare axle and a supply of water and other necessaries, and the two were again driven over the track to meet their watching companions once more. They arrived 40 hours after starting on the long tramp, and never was anybody more gladly welcomed. After repairing the car, the party resumed their journey to Perth, and were able to pass the fire belt in safety owing to the fire having been reduced to mere smoulderings after the change in the wind. On thinking over their adventure, the travellers were constrained to feel thankful that the car broke down when it did, for otherwise the party would have gone into the fire zone some twenty miles further on their journey. If they had done so, they would certainly have perished, for they could not have got back to water nor could they have penetrated the fire zone. Thus the breakage of the axle was a blessing in disguise. It is difficult to know whom to admire the most, the men who tramped fifty miles over the burning sands, or the boy who bravely endured his great trial without complaint. We cannot name them, nor do we refer to them pseudonymously as Boldrewood did with Starlight and Marston (though perhaps the analogy is not altogether a happy one); but they can cut this page out and frame it, and know that it contains an expression of the high regard in which they are held by a fellow man.

REVIEW OF MINING

Introduction.—We are in the midst of another calamitous strike among the coal-miners of Great Britain, brought about by the men refusing to accept the reductions in wages proposed by the masters, following on the decontrol of the industry. A month ago there seemed high hopes of a return of mining and engineering activity, owing to costs of labour, food, and clothing coming down. The new era of prosperity is once more postponed. In metalliferous mining circles the low price and lack of demand for metals have made it necessary for many mines throughout the world to close down. The big American copper producers are idle, and many of the Nigerian tin mines are either closed or working on restricted lines.

Transvaal.—In his speech at the annual meeting of the Transvaal Chamber of Mines, the president, Mr. H. O. Buckle, had a good deal to say about the failure of certain of the labour unions to adhere to their agreements with the Chamber, and appealed to the workers to maintain better discipline among themselves. He pointed out that Rand gold-mining is a declining industry, and that the success of a large part of the operations depends solely on the artificial conditions caused by the gold premium. Under these circumstances any prosperity enjoyed by the mines is really fictitious, and a sound position can only be secured by harder work and lower costs. Sir Lionel Phillips spoke in support of Mr. Buckle's expression of views, and appealed to the men to drop the frivolous frame of mind at present observable in the doings of the unions.

The Government of the Union of South Africa is cutting down public expenditure allowed to the Councils of the Provinces and is abating taxation somewhat. For instance, the Provincial tax on the gold mines is abolished. This tax is not in itself of great amount, but its withdrawal may be taken as a sign of the times.

In spite of the many well-known adverse conditions, East Rand Proprietary Mines has been able to keep going during 1920. The amount of ore milled was much the same as in the two previous years, at 1,460,000 tons, which compares with about 2,000,000 tons in earlier years. The yield of gold was 400,496 oz., selling for £2,209,536, of which about one quarter, or £527,000, came from premium, and the working profit was £192,994. A large proportion of this profit went in debenture interest and redemption of debentures. Mr. E. H. Clifford gives a comprehensive report on developments. He shows that in the bottom levels of the western section some fairly good results have been obtained, and that work in the Cason-Cinderella is promising. On the other hand, only 20% of the ore developed in the Hercules is payable. While the individual developments here recorded might be satisfactory for smaller properties, they are not considered good enough for a big concern like the present company, and the outlook accordingly continues uncertain. The reserve is estimated at 2,410,850 tons averaging 6·1 dwt. per ton, as compared with 2,634,350 tons averaging 6·3 dwt. the year before.

No. 1 shaft at West Springs has cut the reef at a depth of 3,890 ft. The samples taken of the reef averaged 2·04 dwt. over 100 inches. No. 2 shaft is expected to reach the reef in a few months' time. It will be remembered that the development of this property was commenced by means of drifts from Springs, so that work could be done on the reef without waiting for the completion of the shafts, but little information has been published relating to the results obtained.

The south-west shaft at Modderfontein B intersected the reef at a depth of 1,488 ft. The assays gave an average of 29·1 dwt. over a width of 13·9 inches.

Last month it was announced that the Daggafontein company had come to the end of its financial resources without having proved any great amount of ore. An official statement made since then says that owing to the present unsatisfactory condition of the money market it is impossible to raise further funds, so that it is necessary to suspend all mining operations. Since the reconstruction in 1916, the Consolidated Mines Selection group has provided £1,000,000 for shaft-sinking and development. When a favourable opportunity arises, additional capital will be raised wherewith to recommence development.

Adverse financial conditions have made it impossible for Modderfontein East to complete its scheme for erecting the treatment plant recently bought from the Simmer Deep and Jupiter companies. A large sum was necessary for erection of this plant, and money was also wanted for the redemption of debentures, and for an extended campaign of development. As it was found impossible to obtain sufficient money on reasonable terms, it has been decided to postpone the erection of the plant, and to continue to send the ore to the Apex mill. To pro-

vide for paying off the debentures and for development requirements, the Central Mining & Investment Corporation has advanced £400,000 at 8% on mortgage of the property for a period of eighteen months. This, of course, is only a temporary protective measure.

Proposals have been made by directors connected with the financial house associated with Luipaard's Vlei to the effect that the gold produced, or that part produced by low-grade mines, should not be sold on the market in the usual way but should be held in the country and financed by the Treasury. Mr. J. A. Cohen expressed the opinion that if all the mines could deposit their gold for two years with the Treasury against gold certificates the market price of gold could be forced up to 120s. per oz. Mr. F. H. Hamilton's proposal is that low-grade mines should deposit their gold with the Treasury during the months January to August, while the gold premium is low, the Treasury financing them during this time, and that the gold should be realized during the end months of the year, when the premium is high. Mr. Cohen's proposal ignores the facts that the high price now obtained for gold arises solely from the position of exchange banking, and that governments do not pay more than standard price for gold. Mr. Hamilton's proposal might pass if applied privately on a small scale, but in any case the charges for such banking facilities would be considerable. Moreover, the value of the certificates issued by the Treasury against the gold deposited would be influenced by the ordinary laws of exchange.

There is to be no appeal to the Privy Council by Sir J. B. Robinson against the judgments given against him in favour of Randfontein Estates by two courts in South Africa. He has paid the amount due from him, £391,000, so the incident is now at an end.

The Royal Dutch oil company is making an investigation into the oil-shale deposits belonging to the African Oil Corporation in the Wakkerstroom district of the Eastern Transvaal. Particulars of these deposits were given in the MAGAZINE for February, 1918, and November, 1920. It is confidently believed in Africa that the Royal Dutch will exercise the option and spend £500,000 on development.

Rhodesia. — The output of gold during February was 40,816 oz. valued at £288,225, as against 43,428 oz. valued at £293,794 in January. The official figures still contain no explanation of this high valuation of the gold. Other outputs in Southern Rhodesia were: Silver 10,517 oz., coal 41,409 tons, chrome ore 9,325 tons, copper 232 tons, asbestos 2,227 tons, arsenic 17 tons, mica 6 tons, diamonds 23 carats.

The strike to which reference was made last month has been settled in the way expected, that is to say, the men went back on the masters' terms, but there is still some little friction and there are questions outstanding for settlement.

The future of the government of Rhodesia still occupies the attention of the local and imperial authorities. A committee has been appointed by the Imperial Government to consider a number of questions in this connection. Lord Buxton is the chairman of this committee, and as he has only just returned from South Africa, where he was Governor General of the Union, he ought to be able to give some sound advice.

The Cam & Motor company has issued a report of the first month's run of the reorganized treatment plant. During this month (February) 8,200 tons of ore, averaging 44s. per ton, was crushed in ball-mills. Table concentration gave 989 tons of concentrate averaging £10. 9s. 6d. per ton. Of the concentrate, 751 tons was treated, yielding 1,495 oz. gold, worth £6,462 at par. The trial run of the flotation plant commenced on March 7, and the results obtained are very satisfactory.

Nigeria.—Owing presumably to the present financial stringency and the decline in African trade, the purchase by Lever Brothers of the control of the African and Eastern Corporation is not to be completed. Reference was made to this deal last October, and the consent of shareholders was subsequently recorded. The scheme, however, required the consent of the Court, and as a matter of fact the case was down for hearing just as the announcement of the abandonment of the plan was made. It was the intention of Lever Brothers to bring this corporation under the control or management of the Niger Company. The financial stringency was the cause also of Lever Brothers having to issue debentures last month. This issue did not prove acceptable to investors, and a large proportion was left in the hands of the underwriters.

The first bulletin of the new Nigerian Geological Survey, prepared by Dr. J. D. Falconer, has been issued. It deals with the general geology of the central part of the Plateau tinfields. We hope to give extracts in an early issue.

Australia.—Like all copper companies, Mount Lyell is unable to make a profit. Last month the directors had long conferences with the various Unions with a view of arranging for a reduction in wages and other alterations in the conditions of work so that the costs could be cut down. The men, however, refused to

entertain any proposals for a reduction. The Mount Morgan mine continues to be run at a loss, and the directors closed-down operations for a long Easter holiday. Conferences are now being held with the Unions with a view to finding some way of bringing prosperity back, but the prospect is not bright.

The position at Broken Hill is critical, and it is unlikely that the restricted scheme of work outlined last month will be continued for long. Wages, coal, and transport are all too high, and the prices of metals too low. It looks as if the mines would be shut down. It is probable, however, that the treatment of the old zinc dumps will be continued, for the purchasing contract made with the Imperial Government still holds good. As regards the fire at the Port Pirie smelting works, rebuilding has been postponed for the present. An account of this fire has been received by mail. It appears that the disaster originated at one of the burners of the " A " section of the Dwight and Lloyd sintering plant. A strong wind was blowing, and a burst of flame from the burner ignited the woodwork. The flames spread with extraordinary rapidity throughout the building, so quickly that the men on the floor had the greatest difficulty in escaping. The whole building was ablaze within a few minutes. Every effort was made to get the fire hoses to work as quickly as possible, but the wind was so strong that absolutely no check could be given to the flames in the main building. Work was therefore concentrated on the detached buildings surrounding the Dwight and Lloyd buildings, to prevent the spread of the fire to the power-house. So intense was the heat that the roof of the power-house was ignited several times, and gangs of men were employed with buckets and fire extinguishers in keeping down these outbreaks. The damage may be summarized as follows: Dwight and Lloyd plant completely gutted, storage bins badly damaged, conveyors badly damaged, Huntington-Heberlein section damaged but not destroyed, Ropp roaster section damaged but not destroyed, ironstone crusher badly damaged.

The political and economic position in Australia is gradually altering and the stringent legislation engendered by war conditions is already being relaxed. For instance, ores and minerals may now be freely exported, and machinery for dealing with Victorian brown coal is to be bought in Germany.

India.—Owing to the better terms obtained in the realization of gold, and also owing to the fall in the rupee, the Mysore Gold Mining Company was able to make a larger profit during 1920 than in 1919, in spite of the smaller amount of ore mined and gold produced. The 233,502 tons of ore milled compared with 270,425 tons the year before, and the total output of gold was 156,800 oz. as compared with 163,719 oz. On the other hand, the amount realized by the sale of the gold was £804,182, as against £694,317, and the amount distributed was £146,175 as compared with £61,000. It will be remembered that the capital was doubled a year ago so as to provide funds for exploration at depth, and that this new capital ranked for the dividend for the second half of 1920, so that the total return for 1920 was 25% as against 20% in 1919. As regards exploration work, no important amount of ore has been found, but the developments in the bottom of Ribblesdale's and McTaggart's sections are distinctly promising. The ore reserve is estimated at 841,000 tons, a fall of only 29,000 tons on the year. This maintenance of the figure is explained partly by the fact that, with a higher price being obtained for the gold, much ore that was previously unprofitable can now be worked to advantage.

Burma. — The position of the Mawchi Mines, Ltd., reflects the present condition of the wolfram industry. The company's stock of mixed tin-wolfram concentrate in this country has been accumulating, until in January the amount was 939 tons. In addition, there are 123 tons of separated tin concentrate and 18 tons of tungsten powder waiting realization here. Also 473 tons of mixed concentrate is in Burma awaiting shipment. It was thought best under these circumstances to suspend output, and instructions were given accordingly on January 27. The company has borrowed £108,000 on the above-mentioned products from the bankers and others. In order to satisfy the bankers and to put finances in a better condition, the directors offered £60,000 prior lien debentures last November, and of these £25,500 have been taken up. They are now offering the remainder among debenture-holders and shareholders. Mr. C. M. Euan-Smith has recently made an examination, and in conjunction with Mr. John D. Hoffmann has submitted a report on the property. These engineers write hopefully of the future, provided market conditions improve, and are against the abandonment of the properties. The company also has a controlling interest in the Kassa Mining Co., which was recently formed to acquire properties from the Niger Company, and there is still a liability for calls. The Kassa properties have been developed on a small scale, but it is considered best to suspend active operations for the present.

Cornwall.—The gloomy position with regard to mining continues without much hope for an improvement. At the meetings of East Pool and South Crofty there was considerable discussion as to pumping policies, fears being expressed that South Crofty would suffer if East Pool sealed off the old mine and concentrated its attention to Agar and Tolgus. The matter is now before the Minister of Mines, and a suitable working arrangement for controlling the underground water in the district is being sought.

Canada.—The Government is doing everything to discourage a rush to the new Mackenzie River oilfield, so as to prevent a repetition of the distressing events of the Klondyke rush. Particulars of the regulations for granting claims are given elsewhere in this issue.

The Mond Nickel Company has issued £1,300,000 new debenture stock, carrying 8% interest, for the purpose of redeeming the existing £500,000 6% debentures, for providing further working capital for the development of the company's business, for paying off loans from banks, and for the completion of the purchase of the share capital of Henry Wiggin & Co., Ltd., Birmingham.

United States.—The copper position has become so serious that many leading mines have been closed down entirely for a time. Though the output had been restricted, the stocks of unsold copper continued to accumulate, and drastic action became necessary. At present Anaconda, Utah Consolidated, Ray, Chino, Nevada Consolidated, and Calumet & Hecla are idle.

It is announced that Minerals Separation has commenced an action for breach of patent rights against the Jackling porphyry group of copper-mining companies, including the Utah Consolidated and Nevada Consolidated, and other companies using the Callow method of concentration by flotation.

Mexico.—Considerable disturbance in London oil circles was caused by the publication of a statement by Mr. Ralph Arnold in the monthly paper issued by the American Institute of Mining and Metallurgical Engineers to the effect that the Mexican oil reserves would be exhausted in a year's time and that many wells were being ruined by the inroads of brine. The houses interested in Mexican oil have published denials of Mr. Arnold's gloomy forebodings. Mr. Arnold's motives in making the statement in question were probably two-fold. In the first place it was intended as a practical reason for a protest against the policy of the chief producers in America in making such severe cuts in the prices; and secondly, there was a hope that some such statement would deter the Mexican Government from imposing a big tax on oil.

Hungary.—Toward the end of last year it was announced that the Anglo-Persian Oil Co. was negotiating with the Hungarian Government for oil concessions in that country. A company has now been formed called the Hungarian Oil Syndicate, as a subsidiary of the Anglo-Persian, with a capital of £130,000, for the purpose of making the necessary preliminary investigations.

Spain.—For the first time for more than a generation the Rio Tinto Company is not paying a dividend on its ordinary shares. The prolonged strike, and the depression in the copper and pyrites markets, have combined to bring about this result. The company is, however, able to pay the preference dividend and to carry forward a substantial amount.

Persia.—The Anglo-Persian Oil Company has made an issue of £3,500,000 9% cumulative second preference shares, and, unlike some recent industrial issues in other departments of commerce, the shares were eagerly absorbed by investors. The money is required for several purposes. The number of pipe-lines from the oilfields to the coast is being considerably increased, and many new steamers have been bought or are in course of construction. Then the company is preparing to take into its own hands the work of selling its benzine and kerosene production after the present sale contract expires at the end of 1922. The building of the refinery near Swansea has also been undertaken in view of this approaching reversion of control of the refined products.

Spitsbergen.—The yearly report of the Northern Exploration Company for the year ended June 30 last, and the proceedings at the shareholders' meeting at which the report was discussed, naturally reflected the disappointment felt by all parties that the many activities of the company have led to no practical commercial results. The much-advertised magnetite deposit has retired to the background since Mr. Selkirk reported so adversely on it. The company, however, still owns coal lands, and marble, copper, and zinc deposits of more or less value, and it is said that there are indications of oil. The central figure in the enterprise, Mr. Salisbury-Jones, has retired from the board. The Honourable E. C. Pery, D.S.O., is now managing director, and we can only express the hope that his efforts to bring the company into a more prosperous condition will meet with success.

THE OIL RESOURCES OF SOUTH AMERICA.

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INTRODUCTION.—The great and ever-increasing demand for petroleum products throughout the world has at last impressed on both producer and user of oil-fuel the vital necessity of taking stock of existing oil resources. Statistical evidence available from the United States and other oil-producing countries proves conclusively that if the demand continues to exceed the supply at the present abnormal rate, the exhaustion of several of the most productive wells extant may be expected within the next two decades, assuming that no drastic scheme of oil conservation be universally adopted in the meantime. As a matter of fact, the United States Government is fast waking up to the need for economy in this direction, and as producer of nearly 80% of the world's crude oil, any steps taken as a precautionary measure in limiting her oil exports must result in serious consequences for those countries who, like ourselves, are mainly dependent on her for their industrial requirements.

In a recent review of British and Colonial oil resources,* the writer has uttered a warning of what may be quite reasonably anticipated in the near future with regard to our home oil industries, and while disclaiming all idea of oil famine (as several press enthusiasts would have us believe), he has advocated not only rigid economy with existing supplies, but the full utilization of oil-shale and organic substances as sources of oil and, above all, renewed and unstinted enterprise in the discovery of new fields in those countries in which geological conditions are known to be satisfactory. It is with this latter phase of the problem that we are here chiefly concerned, and it is the present intention to indicate the great economic probabilities awaiting extensive development of the oilfields of South America, a continent as yet only in its infancy with regard to oil production.

It has of late years been quite customary among oil technologists to make merely passing reference to South America as an oil-producing continent, opinions being usually of a doubtful character and tempered with no little pessimism concerning climatic and political conditions prevalent there. That there are inherent difficulties attending operations in some of the most promising regions is not to be denied, but they are as nothing compared with those which confront unskilled prospecting in that country and which have done quite as much, if not more, to retard development in the past, as adverse conditions of environment. This brings us at the outset to the statement, applicable not only to South America but to all countries, that the future discovery of productive fields depends entirely on the exercise of technical skill in unravelling complex geological structures, and that it is to the stratigraphical geologist, trained in oilfield technology, that we must look for all ultimate developments worthy of the name; the day of chance as prime factor in oil-finding has passed, and necessity compels us to recognize the indisputable claims of science as its successor. It follows therefore that a brief survey of the main geological features involved must be prefatory to any consideration of the economic potentialities of the continent.

GEO-TECTONICS AND GEOLOGIC FEATURES.—South America presents to us three striking tectonic features which govern the disposition of the rocks composing the continental mass; these are (1) the Western Cordilleras or Andes, essentially the backbone of the continent, (2) the broad Archæan shield forming the Brazilian platform, and (3) the Northern Highland fault blocks constituting the Guiana mountain system. These three dominant structures are responsible for the initiation of the Amazon, La Plata, and Orinoco river systems, spreading respectively over vast plains known as the Selvas, Pampa, and Llanos. These latter unite to form one great central plain which is bounded by the main orographical lines determining the present configuration of the continent.

The Andes stretch for nearly 5,000 miles from Cape Horn to the Caribbean Sea and are made up of a roughly parallel series of mountain chains of varying trend. In the extreme south the range strikes N.W.-S.E., curving round to a N.-S. strike north of the Magellan Straits, a direction persistent to the Bolivian Andes. In southern Peru the line is again N.W.-S.E., which trend it follows to the Peru-Ecuador boundary, whence it partakes of a N.N.E.-S.S.W. direction throughout to the Venezuelan coast-line. The most easterly chain consists of short discontinuous masses of Ar-

* *Discovery*, August, 1920. John Murray, London.

chæan rocks typified by those of Cordoba and the Sierras to the east of the Cordillera Real of Bolivia. These masses are flanked on the west by a continuous belt of mountains stretching from Central Peru to Mendoza, principally composed of Silurian sediments. Further west still and constituting the Central Cordillera of the Coastal System is the main Jurassic zone of stratified sediments and intrusive igneous rocks, overlain in many places by extrusive lavas of recent volcanoes. This vast chain, which includes many of the highest peaks of the Andes, lies adjacent to the Coastal Cordillera, consisting of a mass of ancient gneisses, schists, and sediments of Archæan age; this most westerly belt is particularly conspicuous as defining the general trend of the Pacific coast-line, especially throughout the southern part of Chile and Tierra del Fuego.

The elevation of the Andes as a whole has been due to earth movements operating along lines having an approximate N.-S. trend; but the curious deflection of strike both in Peru and further south in Chile is due to the existence of an older mountain system whose dominant structure lines have not been entirely obliterated by subsequent orogenic movement. The influence of this older system is recognizable in the Archæan chains such as the Sierra de Tandil, striking W.N.W.-E.S.E., across the Atlantic margin of the Patagonian plain, and also in several of the minor flexures of the Bolivian Andes.

The Brazilian platform affords a marked structural contrast to the Cordillera just described. It is composed essentially of a great plateau of Archæan metamorphic rocks upon which rest thick horizontal masses of Palæozoic strata, with an upper covering of sandstone of undetermined geological age (though probably Mesozoic). The average height of this platform is about 3,500 ft., but in many places it is deeply incised by fluviatile action, mainly by the tributaries of the Amazon. We may regard the Guiana Highlands block as part of this Brazilian shield, only presenting a modified structure as it slopes underneath the Llanos of the Orinoco basin. The southern boundary of this basin marks not only the northern termination of this shield but also the line of division between the uniform structure of the latter and the more involved tectonics of the Orinoco basin and the Venezuelan Cordillera, which belong essentially to those of the ancient Antillean continent. This finds ample expression in the dominant strike of the rocks of Venezuela, which is in general E. 15 N.-W. 15 S., and is exemplified by the Venezuelan Cordillera especially; to this direction also the Tertiary rocks of Trinidad conform. West of meridian 64° the tectonic lines tend to swing round to a uniform N.E.-S.W. strike, which gently deflects to the main N.N.E.-S.S.W. trend of the Andes in this region near the Lake of Maracaibo. The Tertiary deposits bordering the lake also conform to this direction.

The E.-W. lines of folding exhibited by the Venezuelan rocks are referable to the main structures of the now sunken area occupied by the Caribbean Sea, and the several islands constituting the West Indies and separating that sea from the Atlantic are but the isolated summits of a mountain chain of the submerged land mass. A glance at a map of the West Indies shows immediately the parabolic form of the main structure lines affecting the disposition of the islands and of that part of the South American continent influenced thereby; they clearly consist of three main concave zones, with concavity facing west, named by Suess the Inner or Lesser Antilles zone, the Median or Greater Antilles zone, and the Outer Zone comprising the Tertiary deposits of such islands as Barbuda, the Bahamas, and Barbadoes. The flattening out of the curve as it passes through Trinidad, across the Gulf of Paria, and through Venezuela, effects, by its E.W. trend, the characteristic north-coast structures to which we have referred.

Thus the natural division of South America into "tectonic provinces," as determined by the three main orographical features with their intervening lowland topography, is a direct result of the differential earth movements which have affected the whole continental mass. We recognize in the Andean Cordillera a continuation of the great North American coastal ranges bordering the eastern margin of the Pacific basin; and to the main tectonics of that basin we can refer the present structural disposition of the Cordillera as a whole. With the Brazilian shield, on the other hand, we are considering an eastern remnant of what has been termed the Brazilio-Ethiopian continent, now submerged beneath the Atlantic Ocean. The Archæan platform of western and central Africa probably represents a portion of this ancient land, as both structurally and geologically the two areas present many features in common. Between the Brazilian shield and the Andes is the wide belt of lowland country of the savanna type which has undergone submergence during past geological epochs. In the Amazon and La Plata basins, for example, we have extensive developments of discontinuous marine and estuarine deposits laid down in an arm of the an-


G.H.
B.S.
SKETCH MAP
OF
SOUTH AMERICA.
SHOWING MAIN TECTONIC FEATURES,
PETROLIFEROUS AREAS, ETC.
TREND LINES OF ANDEAN SYSTEM.
TREND LINES OF CARIBBEAN SYSTEM.
TREND LINES OF ANCIENT MOUNTAIN SYSTEM.
G.H. GUIANA HIGHLANDS
B.S. BRAZILIAN SHIELD
PRODUCTIVE FIELDS
POTENTIAL FIELDS.

cient sea separating the Pacific from the Brazilio-Ethiopian continents. The land to the north of the Orinoco is, as we have shown, structurally referable to the tectonics of Central America and the West Indies.

With this brief survey of the geo-tectonics of the South American continent before us, it is possible to appreciate to advantage the present stratigraphical appearance of its rocks, in particular the sedimentary facies which here specially concern us. It is perhaps superfluous to add that the location of petroliferous areas is in strict conformity with these main structural features, a fact not always valued at its full significance by many engaged in the task of oil-finding. We proceed to a consideration of the main oil-producing regions of the continent with reference to the several States concerned. These may be grouped as follows: The Andean States of Colombia, Ecuador, Peru, Bolivia, and Chile; the Atlantic States of Argentine, Uruguay, Paraguay, Brazil, and Guiana; and the Caribbean State of Venezuela.

COLOMBIA.—In a broad tract of country bordering the coast from Sta. Marta to the gulf of Darien and lying between the rivers Magdalena and Atrato are rocks of Tertiary age which include some valuable petroliferous deposits. A good deal of intermittent work has been carried out in the past in connection with drilling operations, but the results have hardly proved as satisfactory as the geological data would seem to indicate. Recently much more favourable reports concerning the extent and high quality of the oil of this region have come to hand, and development is now proceeding rapidly. The basin of the Sinu River is a specially favourable locality and the wells yield an oil with paraffin base and specific gravity of 0·858. Cartagena is the principal refining centre for the district and is also the port of shipment.

The Tertiary deposits of this area are folded in a N.N.E.-S.S.W. direction, conforming with the strike of the Western Cordillera. Surface indications of petroleum are very numerous throughout the area, but more especially around the Gulf of Urabia; their distribution and general disposition point to geological conditions of some complexity, particularly where the infolding of the Tertiary and Cretaceous rocks is intense.

Other areas have been prospected higher up the Magdalena, near Guamo and La Plata; these are situated in the plain between the Eastern and Central Cordillera, which consists geologically of sharply folded Tertiary and Cretaceous rocks flanked on either side by narrow ridges of Archæan gneiss. On the eastern slopes of the Andes, about 60 miles N.E. of Bogota, is located the Upia field in the basin of the Upia River, a tributary of the Meta. Few details are available concerning this field save that the oil is very pure, free from water, and has a specific gravity of 0·926.

In addition to the occurrences of petroleum noted above, there are large deposits of glance pitch or "manjak" mined at Chaparral on the Saldaño River, a tributary of the Magdalena. About 2,000 tons is exported annually from Barranquilla, for the purpose of manufacturing varnish. Glance pitch, a variety of asphaltite, is a natural desiccated petroleum product which, when free from mineral matter, is known as "manjak." The product from the Chaparral mines contains only 3% of mineral constituents.

The various fields situated in the State of Zulia (Venezuela), some of which extend into Colombian territory, will be considered in conjunction with others in that country.

ECUADOR.—The centre of the petroleum industry in this state is undoubtedly Santa Elena, situated on the north coast of the Gulf of Guayaquil and some 60 miles west of the port of that name. Here the oil is again associated with Tertiary strata composed of limestone, sandstone, and shale deposits, striking practically N.-S., parallel with the trend of the Western Cordillera in this region. There are abundant surface indications within a land radius of thirty miles of Sta. Elena, and development is progressing favourably. The oil has a specific gravity of 0·985, and is obtained chiefly by excavating the shallow trenches in the actual outcrops of the oil-bearing sand or by sinking wells about ten or twelve feet deep. Local conditions and crude methods of production have probably retarded progress in this country, but the possibilities of increased output following on careful geological survey of the fields are extremely favourable.

The Tertiary deposits of this region form a northern continuation of those of Peru, and have been assigned to Miocene and early Pliocene age. They are again found on the Island of Puna, midway in the Gulf of Guayaquil, where traces of oil occur.

In the neighbourhood of San Raimondo on the coast, natural asphaltic deposits are met with, also on Cojitambo Hill, a little to the N.E. of Cuenca. More recently oil indications have been reported from the Pastazza River district, some 130 miles N.E. of Guayaquil. Reports of oil springs from the Quito area should be taken with reserve; the conditions are unfavour-

* Redwood "Treatise on Petroleum," vol. i, p. 103. (1913.)

able to the preservation of oil-pools.

PERU.—There are several important petroliferous areas in Peru, of which the oldest and best known is that occurring as a coastal belt extending from the Gulf of Guayaquil (Malpelo Point) southwards for about 250 miles to Point Aguja. This tract of country stretches inland to the western slopes of the Cordillera, and embraces the well known fields of Negritos, Lobitos, and Zorritos. Its rocks are of Tertiary age, consisting of productive Lower Miocene shales and sands capped by clays, sands, and conglomerates of Upper Miocene and Pliocene age. The strike of the beds is N.S., curving round to N.E.-S.W., to the north of lat. 5° S., in conformity with the change of trend of the main Andean structure line at this point.

Of the three fields mentioned above, that of Negritos is probably the most important; it is certainly the oldest known, as the ruins of the ancient shallow workings from which the Incas used to collect the oil are still to be seen. The Lobitos field is a later development and comprises an area in which a number of highly productive wells have been sunk. These fields, together with that of Zorritos, are being rapidly expanded; in 1917 the estimated production of the joint undertakings amounted to approximately 2,500,000 barrels, a production which is steadily on the increase. The port of shipment is at Talara where there is also a large refinery.

Several other areas in this country are petroliferous, and mention may be made of such promising localities as Mito (Province of Jauja), La Brey in the Chumpi district (Province of Parinacochas), while a later development near Pusi, N.E. of Lake Titicaca, in the Province of Huancane, has shown the occurrence of paraffin oil of high quality. Asphaltic rocks are also widely distributed, especially in the Provinces of Luya and Tarma.

Altogether Peru seems to offer exceptional opportunities for future development, both economically and politically. As a further asset climatic conditions are particularly good, and in this latter connection we may quote Beeby Thompson, who writes as follows: "Favoured by a healthy climate, the tropical heat tempered by perennial cool southern breezes, the absence of rain and desert-like surroundings impose no hardships, and enable work to proceed in a way unknown in any other oil country. Drilling is easy and rapid, no water difficulties occur, and the light density oils are much sought after for the extraction of petrol."* Reports all tend to confirm this view, and while they often make mention of certain geological difficulties encountered in the course of prospecting for new oil-pools, such difficulties are of a purely technical character and should not prove insurmountable as the course of geological survey proceeds.

BOLIVIA. — The oil propensities of this country are as yet comparatively unknown, though from time to time reports of the discovery of oil seepages from the eastern foothills of the Andes are received. The dominant geological structures in this particular region are determined by the ancient N.W.-S.E. lines of folding which, where intersected by the later Andean movements, result in complex quaquaversal structures as yet imperfectly understood.

The most favourable area is around Santa Cruz and to the south, extending beyond the Bolivia - Argentine boundary. Many of the petroliferous indications have been located in association with Lower Cretaceous strata, and in this respect indicate that development should be cautiously prosecuted until a thorough geological examination has been made. Generally speaking this stratigraphical horizon is not commercially productive, though where intimately folded with later sediments, it may yield results of the greatest possible importance. Future geological reconnaissance will probably reveal the presence of Tertiary infoldings, a feature of the country farther south, and conditions may thus be extremely favourable to the preservation of oil-pools. Inadequate geological knowledge, coupled with the facts that the region is somewhat inaccessible and that labour difficulties are very real, have undoubtedly impeded exploration in the past, though with the ultimate development of contiguous areas in Northern Argentine (q.v.), much light should be thrown on the possibilities of the region.

CHILE.—The oil resources of Chile are at present unknown, and our knowledge of the country in this respect is largely limited to surface indications in the north, in the Province of Tarapaca, while in the Maullin River basin and in the Tertiary region to the south, natural gas is being constantly located. Some authorities speak very highly of the oil prospects of this region, and while to a certain extent this may be justified, geological conditions, at all events on the west coastal belt, are hardly satisfactory. Redwood mentions indications of oil in the Puerto Porvenir and Agua Fresca areas (Magallanes Territory), but we have little information concerning this occurrence beyond the mere statement.*

* Beeby Thompson: Oilfield Development, 1916, p. 80.

* Redwood: Treatise on Petroleum, vol. 1, p. 195

ARGENTINE. — The Argentine Republic offers many favourable prospects for the location of productive fields, especially on the eastern slopes of the Cordillera. Large areas of petroliferous rocks are known from the Provinces of Salta and Jujuy, consisting of (?) Mesozoic dolomites, sandstones, and conglomerates in which wells have been sunk with promising results. At many horizons these rocks are asphaltic, particularly in the north, near the Bolivian border. Oil shales of Rhætic age have been located in the neighbourhood of Mendoza, and to the west and south of San Raphael, while further south in the Val de Chillan similar deposits have yielded shale-oil on distillation.

Another oil-bearing region of some importance is that situate on the east coast near Comodoro Rivadavia in the Chubut Territory; this occurrence was accidentally located when sinking an artesian well in 1903, and since that time considerable progress has been made in prospecting.

The mode of occurrence of petroleum and its derivatives in this country is noteworthy; usually the oil occurs either in the form of asphalt or in the fluid state impregnating limestones and sandstones, presumably of Mesozoic age. The production is by no means uniform and a great deal of technical work still remains to be carried out. One of the most promising districts for future exploration is undoubtedly that of the eastern border of the Andes in the Province of Mendoza, where numerous seepages have been reported and examined. In some cases these have been located in Tertiary deposits, and the opinion has been expressed that the oil is not indigenous, but due to migration from underlying Mesozoic rocks. This is a doubtful point and one that requires further investigation. As already mentioned, the sedimentaries are much disturbed in this region and folding has been of a very comprehensive nature, involving both Lower Tertiary and the Mesozoic strata. The latest information shows that there are exceedingly favourable possibilities of oil production from this zone, and exploration will doubtless be watched with considerable interest.

URUGUAY.—The northern part of this country belongs tectonically to the Brazilian Highland mass, and as such presents conditions entirely unfavourable to the accumulation of petroleum. To the south and bordering the estuary of the Rio De La Plata, the country is essentially part of the Great Central Plain system, and may be expected to offer similar oil possibilities to those of the eastern Argentine, though no information of oil occurrences is generally available.

PARAGUAY.—Geologically this country is mainly a northward extension of the conditions obtaining in Uruguay. On its eastern borders it is structurally referable to the Brazilian plateau, though apparently a further element is introduced by the existence of a remnant of the ancient mountain system which can be traced particularly in the Parana basin. Westwards the savanna type of country is prevalent, and prospecting for oil has been of a very minor character, and devoid of commercial results.

BRAZIL.—The petroleum resources of Brazil must, in view of the geological and tectonic conditions, be extremely limited, and although there may be latent possibilities in the Amazon basin toward the interior of the continent, the country as a whole is entirely unsuited to oil production save for that of shale oil which has received a certain amount of attention in the past. In this respect, the bituminous deposits of the Camamu basin in the Province of Bahia have often been described and several attempts have been made to work them on a commercial scale, but so far without a great deal of success; the material is known as "turfa," and it occurs in several areas throughout Brazil, but more particularly along the coastal belt. A long tract of bituminous shale extends from the mouth of the Amazon southward to Porto Alegre, with which this occurrence in the Camamu basin is associated, but it is very impure and of doubtful economic value.

In a recent newspaper article from Rio de Janeiro, the oil resources of Brazil were painted in extremely glowing colours, particularly in connection with shale oil from "valuable deposits in the interior"; these shale deposits were reported to contain a high percentage of volatile matter, and projects on a large scale were being made to develop them. Dr. Alderson, in his book on the Oil Shale Industry (1920), mentions the Brazilian shale deposits as having yielded 44·73 gallons of oil and 19·55 gallons of ammonia water to the ton, but states that they have not been worked commercially. With practically no market for the by-products it is very doubtful whether these deposits would ever constitute a business proposition.

GUIANA.—The Highlands of Guiana are, as we have seen, tectonically a part of the Brazilian plateau, only separated from that vast mass by the basin of the Amazon. Toward the north, in British Guiana, where the land

slopes down to the Orinoco basin, a tract of Tertiary strata makes its appearance, and asphalt has been found at several horizons within this tract, especially near the coast. This knowledge has led to a certain amount of prospecting for oil, and although no important results have as yet been forthcoming, conditions are by no means unattractive, particularly in the region of the Orinoco delta and immediately to the south. The main objection to the area is that of climate; field-work and exploration generally are hampered to a great extent by the exceedingly humid conditions prevalent, and in the two wet seasons by heavy torrential rainfall.

VENEZUELA.—This country, both from the geological and economic standpoints, is by far the most interesting in South America, though partly on political grounds and partly from climatic reasons it has received comparatively little attention until recent years. Owing to the very wide interest now being shown in oil development in this republic, we will deal with it in somewhat greater detail.

We have already seen that tectonically Venezuela, at all events in the north, belongs to the ancient Antillean continent, now submerged beneath the waters of the Caribbean Sea. Along its southern borders its main structures are referable to the Guiana Highland land massif, while westwards the Andean Cordilleras constitute the main lines of upheaval and folding which, in their modified N.N.E. trend in the Maracaibo region, become involved in the main Caribbean tectonics. These fundamental features determine the natural division of Venezuela into four geographic elements, two upland and two lowland tracts; the former the Cordilleran and Caribbean Mountain ranges, the latter the Orinoco Plain and the Maracaibo Basin. The geological significance of these tectonic elements is necessarily very great, and has an important bearing on the location of petroliferous regions in the country.

In the south, a vast area of Archæan granites, gneisses, and schists, constituting the basal complex of the Guiana Highlands, extends well into the heart of Venezuela; the Orinoco Plain separating this area from the Caribbean Hills is chiefly occupied by the Llanos, and is in places densely forested, as along the edge of the Highland block. The Caribbean Hills are composed of gneisses and schists and various metamorphics (The Caribbean Series), of doubtful age, overlain by Cretaceous and Tertiary sediments in many cases in intimate association. Westwards the Cordillera divide into two main ranges of mountains enclosing a great synclinal area constituting the Maracaibo Basin and the coastal plains of Coro; here again the geology is largely Cretaceous and Tertiary formations, though around the Lake of Maracaibo itself and especially along the coastal plains to the east, the Pleistocene and Recent deposits are widely developed.

From the point of view of oil occurrence in Venezuela, we can recognize two main regions, that of the Maracaibo Basin and its tectonic extension to the east, and that lying directly to the south of the coastal Caribbean range, forming a long tract of country stretching from the Orinoco delta westwards through the State of Bermudez. In the Maracaibo region there are at least four well-known petroleum districts; the first is in the neighbourhood of Mara, Limon River basin, S.W. of the Gulf of Maracaibo. Here the oil is found seeping from the rocks near the Limon River asphalt lake; the asphalt itself is worked on a large scale, though by crude pick and shovel methods, and transported by barges down the Limon River to the Gulf for shipment. The second district is that of Bella Vista, near Maracaibo itself, and is one which shows evidence of important accumulations of oil. The third is at Sardinate, on the Sardinate River in Colombia, but extending across the Venezuelan frontier, while the fourth important area is at Colon, south of Lake Maracaibo, in the State of Zulia. Other exceedingly promising areas are known on both east and west shores of the Lake, and also in the State of Falcon near the coast. In all these cases the oil is associated with Cretaceous-Tertiary rocks, though in certain fields petroliferous Miocene deposits have been definitely located. In several of the islands bordering the north coast such as Cubagua, Margarita, oil indications are being constantly found, but no fields have as yet been conclusively proved.

The other petroliferous region in Venezuela, that flanking the southern slopes of the Caribbean Hills, is undoubtedly of great potential importance, if only the very disagreeable climatic conditions can be faced, and the risk of yellow fever be minimized. Geologically and tectonically the area is connected with the southern part of the Island of Trinidad, and evidences of oil accumulation are by no means wanting. In the Orinoco delta itself and in several places to the north, mud-volcanoes, asphalt deposits, and surface oil seeps are known. At the mouth of the Guanaco river there is situated the well known Bermudez Pitch Lake (La Felicidad), having an area of over 900 acres, with an average depth of four feet; it consists principally of very pure as-

phalt, hardened at the surface, but pierced in many places by soft asphaltic and gas exudations; it is being worked on a small scale at the present time by pick and shovel method, the material being transported by trucks to the river for shipment. Not far from this occurrence is a similar deposit in the Island of Padernales, Orinoco Delta, with an area of about 70,000 sq. yd., locally known as "La Brea." Other deposits of this nature are found in the islands of Paquero and Del Plata.

Further in the interior very little oil exploration has been carried out, though indications have been reported by numerous travellers and mining engineers. The country is densely forested in many places and the geology hidden under a thick capping of Quaternary (Llanos) deposits which, in the face of the exceedingly trying climatic conditions, do not invite prolonged investigation.

An excellent small scale geological map of Venezuela is shown in the French edition of Suess ("La Face de la Terre"), 1913, vol. iii., pt. 3, p. 1295, taken from the work of Sievers.

CONCLUSION.—From the foregoing sketch of the Oil Resources of South America, it is evident that a great deal of work remains to be done in prospecting for oil in likely regions, and in further developing fields which have already proved productive. At the present time the oilfields of Peru are obviously the most important in the continent and probably constitute on all considerations the most favourable region for future development. The republics of the Argentine, Ecuador, Colombia, and Venezuela all offer substantial opportunities for profitable investigation, since they include areas in which both geologic and structural conditions are suitable to oil accumulation. The resources of the remaining countries are in the author's opinion more doubtful. The existence of the Pre-Cambrian shield as the dominant geological factor in Brazil, Guiana, Uruguay, and Paraguay, rules out at once the chances of finding oil in commercial quantity in those countries, as the overlying sediments where present are, on the whole, extremely thin and discontinuous. In Bolivia, the structures, as far as we know anything of them at present, are exceedingly complex, and comparatively little is known of the economic wealth of the country in so far as oil production is concerned. Finally, in Chile, where the geology is mainly that of igneous manifestation in some form or other, and where the sedimentaries that do occur are nearly always associated with volcanic material, the prospects do not seem to be particularly encouraging, excepting possibly in the north.

World's Production of Petroleum.—The world's production of petroleum in 1920 is estimated at 688,474,251 barrels, against 554,505,048 barrels in 1919, according to figures collected by the American Petroleum Institute. This represents an increase of 133,969,203, or 24·2%. The estimated production in barrels by countries was as follows:

	1919	1920
United States	377,719,000	443,402,000
Mexico	87,072,954	159,800,000
Russia	34,284,000	30,000,000
Dutch East Indies	15,780,000	16,000,000
India	8,453,000	8,500,000
Roumania	6,517,748	7,406,318
Persia	6,289,812	6,604,734
Galicia	6,255,000	6,000,000
Peru	2,561,000	2,790,000
Japan and Formosa	2,120,500	2,213,083
Trinidad	2,780,000	1,628,637
Argentina	1,504,300	1,366,926
Egypt	1,662,184	1,089,213
France	—	700,000
Venezuela	321,396	500,000
Canada	220,100	220,000
Germany	925,000	215,340
Italy	38,254	38,000
Total	554,505,048	688,474,251

Of the total production in 1920 the United States supplied 443,402,000 barrels, or 64·4% of the world's output. Mexico supplied 159,800,000 barrels, or 23·2% of the world's output. The Alsatian oilfield's production appears under Germany in 1919 and under France in 1920.

Canadian Oil Regulations.—The new regulations relating to the disposal of oil and natural gas lands in the North-West Territories of Canada have been published. They supersede all previous regulations and are retroactive in effect. Permits may be issued to prospect for oil and gas over a maximum area of 2,560 acres for a period of four years. This area may be staked in not more than five blocks, for which five separate permits may be issued, requiring the installation of individual drilling outfits on each location. In the event of discovery, a lease of one-quarter of the area covered by the prospecting permit will be issued, at a rental of 50c. per acre for the first year, and $1 per acre for the second and third years. The royalty on the output is fixed at 5% for the first five years and 10% thereafter. The minimum area of a location is fixed at eighty acres, the remainder of the ground covered by the prospecting permit remaining the property of the Crown. An adequate drilling outfit must be installed on a location within two years of the date of the permit; drilling to a depth of 500 ft. must be conducted during the third year and to an aggregate depth of at least 2,000 ft. during the fourth year. Where these requirements are not fulfilled, the permit immediately lapses without the declaration of a forfeiture by the Crown.

THE APATITE-MAGNETITE DEPOSITS OF DHALBHUM, INDIA.

By E. F. O. MURRAY, Assoc.Inst.M.M.

The author gives particulars of phosphate deposits in India, which might form the basis of an extensive fertilizer industry.

THE pergannah of Dhalbhum is the most easterly of the sub-divisions of the Singhbhum District and part of the Chota Nagpur Division of the Province of Bihar and Orissa. It has an area of about 1,100 square miles, which is divided about equally into cultivated lands and jungle. The northern and southern boundaries of the pergannah run along two irregular chains of hills, while the central portion, drained by the Subarnarekha River, is traversed by the main line of the Bengal-Nagpur Railway. Few of the hills rise to a height of more than 2,000 ft., but those between 1,400 ft. and 1,800 ft. are fairly numerous. They are generally covered by sal forest of varying growth and scrub jungle, while in some parts progress is liable to be both slow and painful owing to the quantity of thorn bushes of various sorts that occur.

The inhabitants of the district belong chiefly to Dravidian stock, but while Santals and Bhumijes predominate, numerous other castes are also to be found. Judged by the average Indian standard they become fairly efficient workmen, but suffer in common with the rest of the country in the time lost in the observance of numerous feasts, festivals, and ceremonies.

The chief ores known to exist in the pergannah are chalcopyrite, apatite, magnetite, hematite, auriferous quartz, and wolfram. Other allied products of economic value include white quartz, potstones, a loose grained quartzite used as a building stone, kankar and tufa, lime, diabase, and granite.

The first geological mention of the district would appear to have been made by Voysey in 1823, but long before this considerable mining had been done by the ancients in search of gold and copper. Numerous small iron furnaces were in operation until recent times, and even now the village blacksmith in remoter parts often falls back on the indigenous ores to supplement his stock of metal. Little information as to the ancient workers is to be obtained from the present inhabitants, but it seems probable that operations were commenced by the Seraks, or lay Jains, and ceased with their expulsion. The only traces at present existing of a former civilization are to be found in occasional ruined wayside shrines built of dovetailed blocks of laterite, and some carvings in either laterite or soapstone; also agate and jasper beads either round or barrel-shaped are sometimes washed out of the soil after heavy rains.

The first attempt at mining on a modern scale was undertaken by the Singhbhum Copper Co. in 1856, but this and the subsequent Hindostan Copper Co. and Rajdoha Mining Co. all failed, though not before some development work and smelting had been undertaken. From such evidence as is now obtainable it would appear that too much money was spent on surface and not sufficient underground while such underground work as was undertaken was disseminated over a lateral extent of 16 miles and little attempt was made to prove the values of the ore-bodies in depth. Of recent years the Cape Copper Co. has acquired some of the interests of the last named, and is now at Rakha Mines engaged in proving the value of the deposits when worked by proper methods.

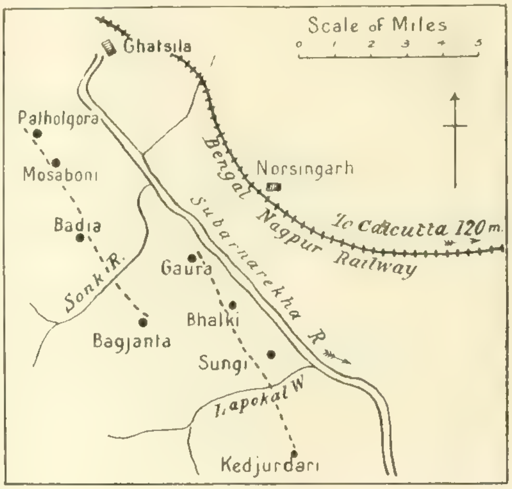
The geology of the district varies considerably in different parts, but the greater portion of the area under review is occupied by the sub-metamorphic (or Dharwar) series of sedimentaries of Archæan age, which are here represented chiefly by talc and mica schists, quartzites, phyllites, and argillaceous slates. Magnesian and hornblende schists also exist, but as in many cases these can be found grading into diabase sills and laccoliths they belong to the epoch following the deposition of the sedimentaries, though also of Pre-Cambrian age. This series of basic intrusives has its chief development just over the northern border in the district of Manbhum, where it culminates in the mountain known as Dolma, 3,060 ft. above sea level, and continues far to the west, forming some of the highest hills along the Ranchi boundary. The early diabase irruptions generally occurred parallel to the foliation of the schists, which strike roughly north-west and south-east, and usually dip toward the north. Both strike and dip, however, are subject to very considerable local variations: but in only one small area toward the north is the latter found to be southerly.

A noticeable feature is that where any large diabase irruption has occurred the surrounding schists are invariably found dipping towards it, thus pointing to their present position being the result of a subsequent uplift. The cause of this movement is to be found in the wide stretches of gneiss that exist both to the north and south of the schist belt, and though the former is outside the borders of the pergannah the portion of the southern batholith included therein covers an area of approximately 140 square miles. This gneiss would appear to have been subsequently intruded by granite dykes and laccoliths, but exposures of these are infrequent and inconspicuous when compared to the basic eruptions of a doleritic nature that later occurred. These last, which are almost entirely destitute of vegetation, vary greatly in size and strike, and are chiefly noticeable for the manner in which they protrude through the gneiss, weathering into blocks and "skulls" of all sizes.

It will thus be seen that two basic and probably two acid irruptions have occurred, any of which might have been wholly or partly responsible for the mineralization of the district. In the present case we are only concerned with the apatite-magnetite deposits, and the most likely period for their genesis would appear to be the early stages of the acid irruptions. Apatite and magnetite are both high-temperature minerals. If further proof were required as to the conditions attaining at that time it is furnished by a garnet schist band in the foot-wall and the association with the deposit of varying quantities of phlogopite mica, tourmaline, ilmenite, rutile, and hornblende.

Erosion has been very severe, as the highest hill of the district, Dolma, was itself once a deep-seated irruption, and in all cases known primary ore is found within a few feet of the surface. It seems probable, therefore, that practically all the deposits existing at the present day were deep seated and that it is only subsequent erosion that has brought them to light. In mining, this theory cuts both ways, for against the possibility of only the lower and leaner portions of some of the veins being left can be set the chance of blind lodes being yet discovered by exploration underground in the less easily eroded portions. In fact, one vein of the latter class has been responsible for practically all the gold, some 5,000 oz., hitherto produced by mining in Dhalbhum, while the quantity of lean quartz and prevalence of alluvial gold even on the lower hill-tops would point to the preponderance of the former type where gold is concerned.

The first notice of the presence of apatite appeared in 1907 (Records Geological Survey of India, vol. xxxvi.), when attention was drawn to its occurrence with some iron ore being quarried by the Bengal Iron Co. near Patholgora. Little notice was, however, paid to this at the time, and it was not until 1915 that the deposits were recognized to be of economic value. The reasons for this were the inconspicuous nature of the deposits, and the unusual colour of the mineral, which was whitish or cream-coloured and had the appearance of felspar. The discovery that this material was apatite would appear to have been more or less fortuitous, and was probably due to in-



vestigation as to the origin of the high phosphorus content of some of the pig iron made from this ore and utilized chiefly in castings. In any case work that had languished for some years and eventually ceased was suddenly resumed with unwonted vigour. This activity led to investigations, and on the cause being discovered prospecting for further deposits was undertaken. This and subsequent prospecting proved that the ore could be traced from Patholgora through Badia and the valley of the Sonk river to Bagjanta, a distance of about 7 miles, where the sequence was interrupted by a quartzite ridge striking almost due north. The probability of a fault existing here was further demonstrated by the discovery of ore about 2 miles north, near the village of Gaura or Goala, where the kyanite rock, which had been a conspicuous feature at Badia, was found to be equally prominent and to occupy the same position in the hanging wall of the

deposit. From Gaura the ore was traced with sundry breaks through Kanyaluka and Bhalki to Sungi, and thence eastwards in lessening quantity to Kedjurdari, which, as far as present knowledge goes, marks the eastern extremity of the deposits.

This run from Gaura to Kedjurdari is of the same length as the former, and though this 14 miles is only a portion of the lateral extent of the ore it would seem to contain all the deposits of economic value. The most westerly existence that has yet been found lies in the state of Kharsawan, 54 miles from Patholgora, so that it has a present known range of 68 miles ; and it is possible that deposits of value may yet be found in the portion traversing Seraikela State, where the outcrop is greatly obscured by alluvium. Parallel to the phosphate belt and at varying distances from it runs the Singhbhum copper belt, which, starting in the hills of Porahat, can be traced for a distance of over 80 miles until it is lost beneath laterite and the alluvium of the Gangetic plain.

The most important deposit of apatite would appear to be at Sungi, and as this is fairly typical of the others a description of this will suffice. The ore is found in a schist band between two beds of quartzite, which together form a ridge about 2,000 yards in length, falling away at either end where it is traversed by nallahs. The main ore-shoot is confined to the central portion of the ridge, where it can be traced almost continuously on the surface for a distance of 3,000 ft., but trenching has also exposed ore in the nallahs on either side. No definite foot-walls or hanging walls exist, the ore being found as blebs and lenses of varying size in a biotite schist belt some 30 to 50 ft. wide. The largest lens so far encountered had a length of 120 ft. with an average width of 12 ft., but owing to the irregularity of the deposit it seems doubtful whether the mean width of the entire ore-shoot would exceed three feet.

The original apatite-magnetite ore has in places been subjected to subsequent hydrothermal action, which has resulted in the original matrix being partly replaced by quartz and chalcopyrite. Small quantities of a greenish yellow uranium mineral, probably autunite, are also found locally along fissures in the ore, but this is of secondary deposition and the original uranium mineral has yet to be discovered.

The order of genesis of the minerals is distinct and divisible into 4 stages as follow:

1 (*a*) Apatite,
  (*b*) Magnetite,
2 Quartz,
3 Chalcopyrite,
4 Secondary Uranium and Copper Minerals.

Until the primary uranium mineral is found, its position in the sequence must remain uncertain, but it can probably be allocated to Group 1. Other secondary minerals include small quantities of malachite, azurite, cuprite, native copper, and bornite, but where found their horizon is limited to within about 30 ft. from surface.

The proportions of apatite to magnetite vary greatly, almost pure specimens of each being obtainable, but from samples taken the average iron content would appear to be about 20 to 25%, equivalent to almost equal quantities of apatite and magnetite by weight. When cleared of magnetite the apatite is of high grade, running over 80% tricalcic phosphate, with about 2% fluorine and 10 to 12% insoluble, but no complete analysis of the ore has yet been made.

Some trenching was carried out on the property during 1916–1917, but real work only commenced in 1918 after the flotation in Calcutta of the Great India Phosphate Co. with a capital of 30 lakhs of rupees. From rumours current about that time, hills containing millions of tons of phosphate that only required quarrying were supposed to exist, and India not being equal to absorbing the output, the company would run its own steamers to other markets, so shares went strong. Samples were sent home, a mill was ordered, and then steps were taken to develop the property. Surprises now came quickly ; the supposed quarrying proposition turned out to be really a mining one if the proposed output was to be obtained, and development had to be undertaken to assure a constant supply of ore. The mill sent out was designed for a lower proportion of magnetite than actually existed, and no allowance had been made for the treatment of run-of-mine fines, which had now to be taken into account. Eventually the company decided to liquidate, as the larger proportion of the called-up capital was still in hand.

Development work done at Sungi during this period consisted of several prospecting shafts on the lode, 2 intermediate drives east and west from one of these, and 2 adits. These last ran into harder ground than could be managed by the local hand labour and had to be suspended until a compressor and drills could be secured ; but before the former had been erected work was shut down and neither reached ore. Though the backs above these adits would only have averaged 150 ft. the lateral extent of the ore-shoot made it possible to win at least 100,000 tons, assuming that the width held, by back sto-

ping and without pumping or hoisting charges; moreover, as the exit for ore was down the valley it was desirable that this should be delivered at as low a level as possible.

In the prospecting shafts considerable trouble was experienced in following ore, owing to the manner in which lenses would suddenly cut out, and all working faces had consequently to be closely watched. At times the only method was to continue on the average dip of 45°, and to trust to one of the 50 sq. ft. of shaft hitting the next lens; but at others a quartz stringer or connecting vein of apatite served as a guide.

At present the apatite deposits, barring those at Patholgora, lie unworked. In view of the urgent need of India for phosphatic manures and the high cost of imported fertilizers, this idleness can be but a phase. The magnetite and apatite are not chemically combined, so that the only requisite is grinding to a sufficient degree of fineness to admit of efficient separation. Probably half the magnetite could be eliminated by hand picking after preliminary crushing (and a ready market exists for this product), thus leaving only some 10 to 12% of iron for removal magnetically. Even supposing complete separation to be unattainable, various methods of utilizing the phosphoric acid contents of the ore are available, but India as usual lags behind the rest of the world and seems to know little of anything but basic slag and acid phosphate, and for the latter no cheap source of acid is yet at hand. This will be remedied, however, when the Burma Corporation starts treating zinc concentrates at Jamshedpur.

IRON ORE DEPOSITS OF QUEENSLAND.

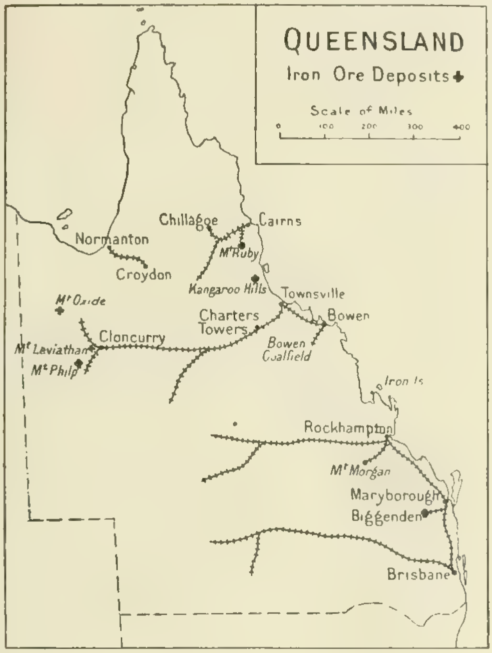
The Author of this article, who has an intimate knowledge of the Mineral Resources of Queensland, gives herewith a description of the principal iron ore deposits in that State, which are to be used in the Iron and Steel Industry about to be established by the Government of Queensland.

INTRODUCTORY.—The State of Queensland has an area of 670,500 square miles, of which over 80,000 square miles is contained in proclaimed gold and mineral fields. Scattered over this extensive mineral area are quite a number of iron ore deposits. The most important of these have been geologically examined and tested in connection with the proposed State iron and steel works, while others have been only cursorily inspected and turned down for the present as being either too small, too inaccessible, or too low in quality to justify consideration as a source of supply for these works. It is advisable to give some details of this State scheme and of the ore deposits, as many people have obtained the erroneous idea that the scheme is based on the Yampi Sound deposits off the coast of West Australia. Another reason for writing this account is that in the article in the MAGAZINE for March, 1919, on Australian iron ore resources no mention was made of Queensland deposits.

A Parliamentary Commission sat in 1917 to inquire into and report upon the advisability of establishing State iron and steel works in Queensland. As, however, little attention up to that time had been officially given to iron deposits, the evidence taken before that commission was inconclusive, and that body confined its conclusions to recommendations for the immediate erection of a furnace with a capacity of 156 tons of ore for the production of pig iron, and of extensive by-product recovery coke ovens and mine equipment, to cost £150,000, and for the appointment of a highly qualified general manager to supervise the erection of this plant and to report generally on the advisability of erecting iron and steel manufacturing works. After the issue of that report, further investigations were made by the Mines Department, a general manager was appointed who arrived in Brisbane in January, 1919, and in February of 1920 a site was determined upon for the iron and steel works, it being understood that the first portion to be proceeded with in connection with those works would be the erection of a furnace to smelt pig iron and of by-product coke ovens.

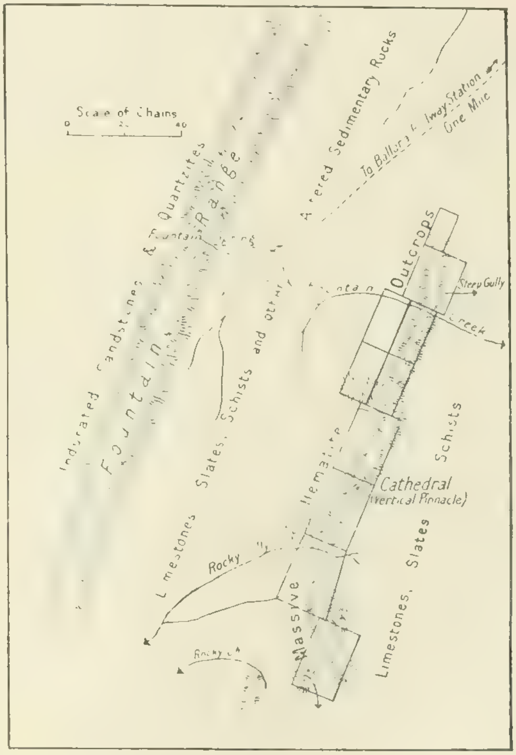
Practically, the decision to go on with these works and to fix the site at the port of Bowen seems to have been based, as far as Queensland is concerned, on the supplies to be obtained from the Cloncurry district (Mount Philp and Mount Leviathan), some 700 miles inland from Bowen, and from Mount Biggenden, in the Wide Bay district, about 500 miles south of Bowen. The deposit on Iron Island, off the coast near Rockhampton, with an estimated deposit of over 2,000,000 tons, is larger than what is expected from Biggenden (about 500,000 tons), but is probably not taken into account because it is leased to the Mount Morgan Company, which obtains its ironstone flux from there. It is probable, of course, that many more iron ore deposits will be found in Queensland, but the Government no doubt thinks there

are already enough to go on with. The present requirements of the Broken Hill Proprietary's iron and steel works at Newcastle, New South Wales, are about 260,000 tons per annum, and the general manager of that company has stated that as he can see about a hundred years' supply of ore at the Iron Knob, in South Australia, whence his works obtain it, he is not worrying about anything after that. On the same basis, the 22,000,000 tons estimated to be available in the Cloncurry district, Queensland, would



keep the proposed Queensland works going for 85 years, while another 13,000,000 tons at Cockatoo Island, in Yampi Sound, West Australia (see the MAGAZINE for October, 1920), which the Queensland Government has bought, to blend with the Cloncurry ores, will add another 50 years' supply, or 135 years in all; and it is reasonable to suppose that the Queensland Government, like the manager of the Newcastle works, is not troubling about the "thereafter." If they are, there is another possible 20,000,000 in Mount Philp that may afford a further lease of existence of over 70 years.

MOUNT PHILP.—The largest iron ore deposit in the Cloncurry district, and indeed in Queensland, is that known as Mount Philp, a comparatively recent discovery lying from two and a half to five miles south-westerly from Ballara, a railway station sixty-three miles in a south-westerly direction from Cloncurry, and 664 miles by railroad to Bowen. The Mount is a range of hills and peaks, consisting of enormous outcrops of ironstone, the adjacent rocks being altered sandstones, quartzites, calcareous and ferruginous slates and schists, with crystalline limestones and dolomites. It has been examined by Mr. B. Dunstan, the Chief Government Geologist, and is described by him in a bulletin on North-West Queensland, issued last year. Parallel with and about a mile to the west of Mount Philp is a precipitous elevation



MOUNT PHILP IRON DISTRICT.

called the Fountain Range, consisting of a narrow belt of indurated sandstone rising prominently between other soft and more easily weathered rocks. The attached sketch plan, as prepared by Mr. Dunstan, shows the position of Mount Philp and the Fountain Range, together with some of their geological features. The country on the western side of the range is said to offer natural facilities for the conservation of water.

Mr. Dunstan reports that the mountain is chiefly hematite; magnetite is occasionally present, and there are impurities consisting mostly of free silica. No place was seen in which the percentage of silica was not high, but that of other impurities in every part of the

lode tested was distinctly low. The following table gives characteristic analyses :

ANALYSES OF MOUNT PHILP ORE

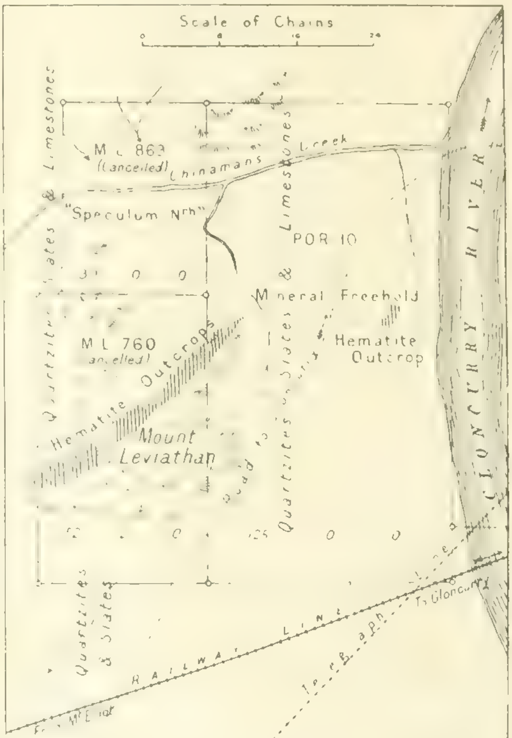
	No. 1. %	No. 2. %
Iron	56.2	52.8
Moisture (at 15 C.)	0.2	0.1
Loss on ignition	slight gain	2.3
Silica	19.5	23.0
Alumina	0.7	0.4
Lime	trace	trace
Magnesia	trace	trace
Manganese oxide	less than 0.3	trace
Phosphorus	0.023	0.03
Sulphur	0.01	0.01
Titanic oxide	nil	nil

It should be explained that analysis No. 1 is the average result from 16 samples taken from all parts of the outcrop by the Government Assayer at Cloncurry, while No. 2 was taken by the Chief Government Geologist, and was made up by sampling all the places from which the 16 samples came. Assay samples taken some years before for the purpose of utilizing some of the ironstone as a flux for copper smelting are said to have shown 17% of silica. The proportion of this impurity would appear to average about 20 per cent.

There is, judging from appearances, a great uniformity in the composition of the ironstone, and the very minute transparent silica grains present could be seen in every specimen examined. It had been suggested that the high percentage of silica might be due to the leaching out by rain of the iron from the surface outcrops, and leaving behind on the exposures an excess of silica; but Mr. Dunstan says there is an absence of porosity and that leaching effects were not apparent, a feature due no doubt to the iron oxide being in a ferric condition, the most stable form in which it occurs in nature, and apparently to the silica being in a free state, instead of in combination with basic substances.

In arriving at a rough estimate of the quantities of hematite in the Mount Philp lode, it is explained that the outcrop of that lode can be observed for miles from the top of one of the pinnacles, but that a length of two miles along the main portion contains all the measurable quantities of ore, outside of which, doubtless, there are other large quantities more or less obscured. Within this limit of two miles the lode varies from 50 to 150 ft., the approximate average being 100 ft., while the height varies from 50 to 500 ft. above the level of Fountain Creek, which cuts through the range at the north end, 150 ft. being taken as the average in this direction. Within these dimensions, Mr. Dunstan says that there must be at least 10,000,000 tons more or less under cover, making altogether an actual tonnage of about 20,000,000 tons.

As the lode has been worn down to the level of the surrounding country where Fountain Creek crosses it, and a splendid working face quite free from overburden has been naturally exposed at this spot, the facilities for working the lode can be made remarkably easy. To this face a short railway from Ballara can be very easily constructed. Farther north and south other precipitous faces are exposed at high positions, and at these places the ironstone can be quarried very cheaply and conveyed by means of shoots and other mechanical devices to trucks below.



MOUNT LEVIATHAN IRON DISTRICT.

MOUNT LEVIATHAN.—Mount Leviathan was first brought into notice as far back as 1898, when the then Queensland Government Geologist described it as "a mass, say 200 ft. high and a quarter of a mile in diameter at its base, of the purest possible iron ore." That it was not "the purest possible iron ore" was discovered many years afterward by the general manager of the Mount Elliott Copper Company when looking for a flux for use in copper smelting, and, as will be seen, its size is almost insignificant beside Mount Philp, which probably nobody except aborigines had seen in 1898. Mount Leviathan was examined at the same time as Mount Philp by Mr. Dunstan,

who gave a brief description of its geology and analyses of its ores.

The Mount is a prominent landmark just outside the town of Cloncurry, 600 miles by rail from Bowen. It forms an elevation about 270 ft. above the surrounding plains, and is a large mass of ironstone associated with quartzites, schists, breccias, and limestones, belonging to the Cloncurry (? Silurian) Series. In outline it is an irregular, lens-shaped lode, lying at an angle across the upturned edges of the sedimentary rocks, while the strike of the lode is north-east and south-west with the sediments trending north and south. A small portion of the hematite is very pure and coarsely crystalline, but the main mass contains a high percentage of silica and is frequently traversed by veinlets of quartz. Magnetite does not appear to be present in the lode, although magnetic polarity is to be observed in several places.

As showing the composition of the ore, three analyses are given in the accompanying table. The first, which is lowest in silica, is typical of the portion of the lode that is smallest in quantity, while Nos. 2 and 3 represent what may be expected to be the composition of bulk quantities.

MOUNT LEVIATHAN HEMATITE ANALYSIS.

	No. 1.	No. 2.	No. 3.
	%	%	%
Iron	62·0	56·5	57·1
Moisture	0·1	0·1	0·4
Loss on ignition	1·8	1·2	
Silica	8·9	17·0	17·5
Alumina	2·0	1·4	2·5
Lime	trace	0·2	trace
Magnesia	trace	trace	trace
Manganese oxide	trace	trace	trace
Phosphorus	0·11	0·08	0·06
Sulphur	0·04	0·05	0·006
Titanic oxide	nil	nil	nil

In forming an estimate of the quantity of ore in the lode, a cursory examination by Mr. Dunstan showed that the deposit could be divided into three sections, of which the southern part probably contains a maximum of 1,500,000 tons, and the central and southern portion about 500,000 tons, making a total of 2,000,000 tons.

MOUNT BIGGENDEN.—Mount Biggenden was worked many years ago for gold and bismuth, and in the operation of the mine considerable quantities of iron ore were proved. The Mount is 4½ miles from the Biggenden railway station, which is 54 miles from the port of Maryborough. The main deposit consists of magnetite with patches of calcite and disseminated bismuth ores. A belt of slate, 10 ft. thick, on the west separates the main magnetite outcrop from the smaller ones, while another patch has been exposed east of that in an open-cut.

One of the Queensland Government geologists (Mr. E. C. St. Smith), who was deputed to make an examination of iron deposits in view of the establishment of iron and steel works, in 1918 made an exhaustive inspection of the magnetic iron lodes of Mount Biggenden, and took a complete set of carefully averaged samples of the iron ore there. These gave the following results:

(*a*) Average sample of the whole of the ore at the main shaft dump (at least 4,000 tons) analysed: metallic iron, 59·0%; lime (CaO), 0·6%.

(*b*) The average samples obtained from different portions of the deposit ranged from 55·5 up to 64·9% of metallic iron and from a trace up to 2·8% of lime (CaO).

A general average of the medium-grade ore from the whole deposit showed the appended analysis:

	%
Water at red heat	0·3
Silica	7·7
Metallic iron	57·7
Alumina	5·1
Lime (CaO)	3·8
Magnesia	0·6
Phosphorus	0·04
Sulphur	0·13
Bismuth	0·05
Manganese	0·24

It is estimated that at least 500,000 tons of good ore can safely be relied upon as being available on this property, "with the extreme probability of a much greater tonnage being ultimately developed by exploitation."

Some of the Biggenden ore has been reduced to pig iron at the Ipswich railway workshops. The experiments were made in an unsuitable furnace and under very crude conditions, but the result was sufficient to show that the physical character of the ore, containing as it does calcite finely disseminated throughout, renders it an ideal smelting proposition as regards fusibility.

Scottish Water-Power.—The British Aluminium Co. is reviving its scheme for producing hydro-electric power from the waters of Lochs Trieg and Laggan and of several rivers in the same neighbourhood. The company is to be called the Lochaber Power Co., and the funds will be raised by the issue of 3,000,000 shares of £1 each and of £1,500,000 debentures. The proposal is now before the Secretary of Scotland. Another Scottish hydro-electric venture is the Grampian Electricity Supply Co., which provides for the erection of five generating stations and the damming of five rivers and five lochs in northern Perthshire and the eastern part of Inverness. Two of the stations will be at Blair Athol and Kingussie respectively.

LETTERS TO THE EDITOR

Cumberland Iron Ore.

The Editor:

Sir—The discussion as to the growth of hematite in Cumberland follows conventional lines. The question put is: What is the origin of the ore or what is the source of the iron? Doubtless very much more is passing in the minds of the participants than appears on paper, and therefore, feeling sure that this is so, I would suggest that the same subject matter may be treated with a different end in view. Granted that we have some fair working hypotheses as to the *origin* or history of these deposits, it may be asked what is the *meaning*, or what might be the meaning, for the world to-day of all the impressions gained during their working and study in the past fifty years.

Is it possible or desirable to continue the quest of origins any further without turning round on all the forms of thought and expression which have served for the working out of the hypotheses so far put forward? Are not accepted theories and criteria capable of improvement through the very facts of iron ore occurrence in particular? Knowledge of these facts is spread through the community; cannot it be unified for purely inductive purposes?

The criteria which Mr. Kendall uses with so much acumen have most certainly lost their hold. They derive mostly from the observation of *external* processes, such as sedimentation, erosion, etc. They miss, for the most part, the possibilities of *internal* change, and naturally so, for at the time when they were evolved such observations of internal change as those of Mr. Kendall himself had not been made.

There is no chance for rational discussion of chemistry or dynamics so long as we speak in terms of "crust." A crust in which iron ore is replacing limestone is ipso facto no crust. Of course, while we are occupied with one pocket of hematite, it is convenient to regard all the rest of the world as being at a standstill, and at every step of our observations our instincts and logical method incline our judgments in this direction.

But is the rest of the world at a standstill? The creep of the iron in its field of action, "the limestone," is but an example of simultaneous creeps the world over. Surely this world-wide field of internal change should ever be before our minds when discussing the chemistry and physics even of one pocket of hematite. As it is, we are obliged for the present to use terms borrowed from stratigraphy whose ideals are quite different. The piecing together of the "record of the rocks," the piling up of a solid crust is the stratigraphic ideal. Those parts of the structure which in the piling were least likely to change give the stratigrapher his clearest data; those parts which in the piling were most likely to change and obliterate the evidence of their origin, have changed or disappeared altogether. Hence, through the survival of stable rocks or stable configurations we are liable to take these as "normal." As it were, all the "crust" ought to be composed of fossiliferous strata, if untoward accidents did not happen (see Huxley's lectures).

But if we have neglected the less stable portions, or the factors of instability normally present in the piling up of the so-called crust, the effects of their changes incline us to infer cataclysmic processes. An ideal of a non-dynamic solid crust logically requires or leads to the inference of special disturbing forces. Fossiliferous strata being, as it were, the normal, then "igneous" action, "metamorphic" action, are discovered to be due to something abnormal to the ordered life of the land and sea.

The question at issue in Cumberland is one of internal change between chemical substances brought within range of one another at various epochs as stratigraphy indicates. The infiltrationists, I understand, take this view and probably most of them have much more in mind than the mere trickling downwards of ferruginous waters. Mr. Kendall's remarks about the breccia and the included pieces of hematite are not very convincing on paper, though in the field they might have a good deal of force against simple infiltration. "Angular" pieces may be replacements, and experience suggests that a "breccia" might well contain sporadic replacements, so sensitive do the processes involved seem to be. In any case the larger question of interaction between the components of "sediments" remains the same. Mr. Kendall, however, connects the ore with the greenstones, the "volcanic" rocks, and, as is well known, hematite and greenstone do occur together almost universally. Suppose then that the greenstone is also a product of *internal* change, and does not come from *inside* the "crust;" what then? Suppose normal inclusions of salt, etc., unstable elements in crust-*building*, led to the *growth* of greenstones?

Returning to the opening sentences of this letter, I suggest that the two hypotheses preferred by Mr. Atkinson and Mr. Kendall are, if treated broadly, not mutually exclusive. On the contrary, if the data found to support either be clearly and firmly held, they might both be put to the highest possible uses. Many hema-

tite deposits in Spain occur in close association with the Trias in all sorts of positions, and with "igneous" rocks. Would it be worth while to compare them very carefully with Cumberland? Cynicism suggests that iron being such a ubiquitous element, and iron ore being indefinable through its many varieties, the tracing of such connections may be futile. If, however, a sufficient number of instances be considered and a sufficiently broad outlook be maintained, the universality of iron, the glory of its many colours, forms, reactions, and associations may provide just that illumination for which the world waits to-day on the subject of the continuity of development of rock species.

Let the data from Cumberland be collected and compared with similar data, from, say, Bilbao, Almeria, Lake Superior, India, and Brazil, and I am sure that we should be well on the way towards taking a more credible view of the "igneous" rocks than is at present current among the mass of men. The great work done by Van Hise and his collaborators at Lake Superior requires revision. The question of the "greenalite" could, I imagine, be illuminated by comparison with certain features of the Bilbao district.

The most striking suggestions, however, come from the tropics. In this letter I cannot enter upon this subject, but merely state my belief that, by way of iron ore, the new knowledge and new suggestions from the tropics could be brought into touch with the older order of thought which grew up in Europe, and the result would be to the delight of all concerned if they will have the faith to try it.

In the meantime in Cumberland let the infiltrationists be bold but not neglect Mr. Kendall's greenstones. It must already have been suggested that the source of the alkalies in the igneous rocks of the region may be sought in sodium and potash deposits of the Trias or at least in the seas which have swept over Cumberland from time to time. Yet such a hypothesis can hardly be discussed in terms derived from the "crust" view of the earth. If, however, we suppose that alkaline silicates can grow in a field now partially and imperfectly represented by the "stratified rocks," sometimes with high temperature and consequent complications, sometimes without, a comparative study of iron ore regions might help towards a different view.

Perhaps you, Sir, may allow me to return to the subject in a later issue.

J. H. Goodchild.

London, March 25.

Cementation Process and Vein-Filling.

The Editor:

Sir—The lecture on the cementation process delivered by Major Standish Ball at the Mining and Metallurgical Club last month was extremely interesting from several practical points of view. The building of an underground dam and the cementing of diamond-drill holes are within my own experience, but the cementing of drill-holes, in my case, was undertaken merely for the purpose of solidifying broken ground which was subsequently drilled. I have had no experience of filling underground fissures or cavities with cement in order to keep out water (though if such water carried "silt" of any kind the matter might require to be dealt with by lining or cementing), and until the above lecture I had not seen specimens of fissured rock which had been subjected to the cementation process.

A cursory examination of one of the specimens exhibited at the lecture suggests that considerable valuable information as to vein-filling might be obtained by an examination of many specimens mined from rock which has undergone the treatment. If those in charge of cementation work are made aware of the great interest which attaches to information on the circulation of cement and other liquids or semi-liquids in fissured rock, I am inclined to the belief that much valuable information would be collected by them, information too which might be of considerable economic value and might be a means of practically demonstrating matters about which hitherto we have only been able to speculate.

Further use for cementation, it occurs to me, is in connection with wells and bore-holes used for water supplies. Some thirty years ago I carried out a lot of tests in connection with the sinking of a large well with a deep bore-hole, and also made many tests of older wells which had become brackish by infiltration of sea-water. From the results then obtained, I believe that there should be considerable scope for increased use of the cementation process for the purpose of shutting out surface drainage, or underground feeders of exceptionally hard or brackish water from well waters intended either for domestic or technical purposes.

Stephen J. Lett.

London, March 17.

[Mr. Lett's suggestion that engineers should study the process of "vein-filling" in cementation is a good one, and they are encouraged to send the results of their investigations.—Editor.]

BOOK REVIEWS

Economic Mineralogy. By THOMAS CROOK. Cloth, octavo, 492 pages, illustrated. Price 25s. London and New York: Longmans, Green & Co.

The author states in the preface that the book is intended for those who wish to restrict their attention to the utilitarian side of the subject, and this aim is kept in view throughout the book. After a brief introductory chapter, the crystal forms of minerals are summarized in Chapter 2, it being stated that this is intended more as an introduction to crystal optics than as crystallography. The next chapter deals somewhat briefly with the physical characters of minerals, and includes clear descriptions of the construction and use of the Jolly balance and of the Westphal balance so far as the determination of the densities of liquids is concerned, but the use of the instrument for the determination of the densities of solids is not described, nor is the hydrometer mentioned.

Chapter 4 deals with the elements of crystal optics, and the author is to be congratulated on having dealt with a subject which gives some difficulty to the beginner in an extremely lucid manner. Then follows a chapter on the chemical examination of minerals, and one on the physical analysis of crushed rocks and alluvials which is thoroughly good. One notes, however, that the vanning shovel is not mentioned though the principle of vanning is suggested. The notes on heavy liquid, magnetic, and electrostatic separation are all that the student should require.

Chapter 7 deals with the geology of mineral deposits, and is necessarily brief and somewhat superficial. It includes a good classification of the deposits and a summary of the deposits in relation to the chief periods of igneous intrusion and orogenic movement.

The next three chapters deal with the descriptive mineralogy of the minerals arranged in groups as ore-minerals, gem-minerals, and miscellaneous economic minerals. The minerals are arranged according to the metals, which is justified by the list of occurrences and associations of the ores of each metal at the end of the description of its minerals. For instance, the description of the lead minerals is followed by four pages dealing with the chief occurrences of lead ores and their associated rocks and minerals.

A series of determinative tables concludes the volume. In the first the minerals with metallic or sub-metallic lustre are tabulated with their physical characters, while the minerals with non-metallic lustre have columns for refractive index and birefringence instead of colour and streak. This is a decidedly useful innovation. A table grouped according to specific gravity follows, and finally a table of some minerals grouped according to colour. It is doubtful if this last is of much assistance to the student, who is scarcely likely to call molybdenite black, or covellite either in many specimens.

The book is well printed and arranged, and the illustrations are good.

The present writer sympathizes with the author in his plea for the microscope as an aid to the quick identification of minerals, and would suggest that a description of the use of the eye-piece micrometer might be usefully added in a future edition.

The book can be strongly recommended to the mining engineer and the economic geologist.

E. H. DAVISON.

Manganese: Uses, Preparation, Mining Costs, and Production of Ferro Alloys. By C. M. WELD and Others. Bulletin published by the United States Bureau of Mines.

Before the war the world's output of manganese ore was furnished by the Caucasus, India, and Brazil. The Caucasian output ceased in 1914, and the demands of the European Allies were met from Indian sources, leaving the Brazilian supply for the United States. Although production in Brazil was largely increased during the war, the quantity sent to North America was insufficient, more especially as submarine activity reduced in quantity British supplies of ferro-manganese reaching the United States. A comprehensive survey of the domestic deposits was undertaken by the American Bureau of Mines, and their intensive development followed; while the Ferro Alloys Committee of the American Iron and Steel Institute endeavoured to modify the practice at steel works, so that lower-grade ferro alloys, made from American ores, could be used in place of the higher-grade material preferred and hitherto used. In the pre-war period, the output of manganese ore in the United States was negligible, but had the Armistice not intervened, it would have reached 300,000 tons of manganese ore containing not less than 35% manganese. This, together with the Brazilian and Central American supply, as well as the modifications in steel-works practice, enabled a stock of one year's consumption of ore to be accumulated in 1918.

With a view to assisting producers of manganese ores, the Bureau of Mines published

mimeographed bulletins dealing with the industry from time to time, and these reports are now published in a more permanent form as Bulletin 173.

This work is a valuable production, and reflects credit on all concerned in its preparation. While primarily prepared for American use it contains so much material not hitherto available, that it cannot fail to be of value to all interested in the utilization of manganese ore. It is evident that much information, which in normal times might be considered confidential, has been freely placed at the disposal of the compilers of this bulletin, although two firms are mentioned as having refused their co-operation in the investigation. The bulletin contains eleven chapters, each constituting a separate report on a definite subject by different observers, and consequently there is a certain amount of overlapping, which is recognized.

Chapter 1 deals with the uses of manganese, prices, and statistics. It is acknowledged that the Price Schedule of May 28, 1918, which refers to 95% of the manganese consumed in the United States in steel production, is mainly historical, for although following the Armistice prices remained high, the recent heavy fall in ocean freights has brought about a 66% reduction in the figures given. It is probable also that the penalties for silica, phosphorus, etc., relaxed during the war period, will be re-imposed as supplies become more plentiful.

Chapter 2 discusses the uses of manganese other than in steel making, which are responsible for increasing consumption. The detailed information regarding the physical and chemical requirements of the manganese dioxide ore for dry cells, glass making, and for paints is most useful. The penalty for iron, not imposed during hostilities owing to the cessation of supplies from the Caucasus, will probably not be re-introduced, as only copper, nickel, and cobalt minerals are now considered prejudicial in ore used for dry cells. Mention is made that manganese ore is no longer used for making chlorine gas, as the latter is an abundant product in the manufacture of caustic soda and potash.

The use of manganese ore in the manufacture of manganese bronze which replaces steel effectively, when subject to the corrosive influence of sea water, is also dealt with, and it is pointed out that only 0·05% of manganese is usual in the high-grade alloy, its function being as a carrier for the iron necessary to ensure the required strength and elastic limit.

Chapter 3 deals with the problems involved in the concentration and utilization of domestic low-grade manganese ore. The American mineral is mostly the result of secondary concentration, and often occurs as shallow deposits of nodules, or irregular masses disseminated in clays. The effect of associated impurities is discussed, and reference is made to calcination of the carbonate, which, however, would only be effective with low silica contents, owing to the tendency to form silicate of manganese.

A list of concentration processes is given, and cost data which show the beneficial effect of treating mineral which would otherwise be unsuitable for ferro-alloy manufacture. The figures refer to cherty California ores low in iron, and would require serious modification for other types of mineral. The plant used is not described, but the ratio of concentration is 2 or 3 to 1, and the war-time cost appears low, at 75 cents per ton of finished product.

Mention is made that the separation of silica, when chemically combined, cannot be carried out by wet or gravity processes, and this fact prevents the utilization of large deposits of manganese silicate ores in the United States, and also the successful beneficiation of the waste material at some Brazilian and Indian mines.

Chapter 4 deals with the preparation of manganese ore. The picking and screening of manganese ore without the assistance of water, referred to as dry mining, is mentioned as a temporary expedient before the erection of a washing plant, but to be effectual it requires a minimum of 10% of ore, and even this would be insufficient in normal times. It is asserted that log washers have treated successfully very lean material, but a ratio of ore to gangue of 10% is considered a fair average. Associated iron having a similar specific gravity requires to be hand-picked. Flow-sheets of several concentration plants are given for mineral associated with clay, followed by a description of a standard arrangement consisting of grizzlies 2 to 4 inches between bars, log washers, revolving screens, picking belts, jigs, and shaking tables. Dry concentration is referred to as applicable where water is scarce, and a plant is described which, however, had not been operated on a commercial scale when the report was written. It consisted of a revolving drum where the material would be dried before passing on to a revolving screen, from which the coarse material would discharge on to a picking belt, the smaller sizes of material being dealt with in jigs.

It may be noted here that the installation of washing plants, some years ago, enabled the large waste heaps, accumulated around the Caucasian deposits since the mines were first

operated, to be successfully beneficiated at a low cost. Washing plants were also operated prior to 1914 on the detrital ore of the famous Morro da Mina deposit in Brazil, and in the Bukowina.

Chapters 5 and 6 deal with the leaching of manganese ore by sulphur dioxide, and the Jones direct-reduction process for the production of a silico-manganese alloy. Both these processes were only investigated as a war measure, but it is suggested that the leaching process might be applicable to mineral containing copper, lead, or zinc; while the Jones system might be used in the preparation of a manganese alloy from ores in which iron is so intimately associated that ordinary methods of gravity or magnetic separation are impracticable. If the Jones process could be made economically sound, it would have a wide field of usefulness, for manganiferous iron ores are widely distributed. The process is in two stages; in the first, iron and slag containing most of the manganese is produced; and in the second stage this latter is smelted to produce a manganese alloy.

Chapter 7, on the cost of producing ferro-grade manganese ores, deals with a difficult matter, inasmuch as the principal factors have varied so greatly during the war and since. The manganese ore output of the United States during the war consisted of 20% carbonate ores and 80% oxide mineral. The former was got by mining underground and required no concentration, but the latter was associated with clay, chert, etc., and required treatment. Many of these deposits are erratic and others give place to silicates in depth.

Much of the domestic mineral was hand-cleaned, but where it was mined and sent for treatment, the average cost was $7·50 and treatment $6·50, or say $14·00 in all. The milling costs differ widely from those already referred to, and the presumption is that the ratio of concentration and quantity handled varies in the two cases. The total cost at furnace of the domestic mineral during the war is put at $0·65 per unit of 40% ore, although it is calculated that this could be reduced about 15% in normal times. Of the foreign ores only those of Cuba and Brazil are considered; the first is of similar grade to the domestic mineral, but the second normally contains 50% manganese.

The Brazilian costs are in dollars, but in view of economic changes, it would have been preferable also to give the native currency costs and rate of exchange at the time of making the estimate. The average costs into ship of Brazilian ore at Rio is put at $15·00 in 1918, and this together with $15·00 ocean freight is equal to 67 cents per unit for 45% ore, at American ports. The authors endeavour to estimate future prices and suggest that if ocean freight falls to pre-war figures, it would be possible to place Brazilian ore in the United States at 40 cents per unit. These conditions have been reached, for the Brazilian exchange has fallen to 10d. and ocean freights to a little over a third of those of 1918. It is therefore doubtful if, under normal conditions, American ores can be produced in competition with foreign supplies, unless assisted by a high protective tariff, which is at present under discussion by the Government. The work of the Bureau of Mines has shown, however, that a good supply of manganese ore can be produced in the United States, and if some economically successful method could be evolved for beneficiating the manganese silicate ores, it is probable that the country might, in time of national stress, be self-supporting.

Chapter 8 deals with the production of manganese alloys in the blast-furnace. Particulars are given of the operation of a number of furnaces producing ferro-manganese and spiegeleisen, the observations extending over 10-day periods. The working of a blast-furnace making ferro is more regular than when producing pig iron, but the problem of getting the manganese into the alloy, instead of into the slag, is not easy. In order to account for the greater amount of fuel required, it is pointed out that the manganese is reduced from its oxide by solid carbon near the tuyeres, and, as the CO_2 resulting is again reduced by solid carbon, there is a loss of heat. The balance of heat units is used in heating ascending gases, which are three times greater than in pig iron furnaces per lb. of ferro produced.

An elaborate analysis of the operation of the furnaces is made, and both the slag and stack losses are found to vary within wide limits and average 14·7 and 12·8%. An investigation was made into the effect on these losses of (*a*) quantity of fuel, (*b*) basicity of slag, and (*c*) rates of driving, and it was found that the percentage of manganese in the slag was reduced by raising blast temperature, increasing basicity of slag, and charging more coke; while it was increased by fast driving and carrying a greater slag volume. The volatilization or stack loss did not appear to have any relation to these factors.

The authors state that by making five changes in practice, the eleven furnaces considered could have raised their recovery to 79%, and using the same ore, could have increased their

tonnage 59% and also increased their profit appreciably. The changes suggested are: Using a better quality of coke, using a better grade of limestone, using less fuel, running with a more basic slag, and driving faster.

In dealing with the manufacture of spiegeleisen, it is pointed out that to obtain manganese, the smelting of manganiferous iron ore takes 78% more carbon than when making ferro-manganese, although this may in part be due to the high ratio of silica to manganese in these ores, as compared with manganese ores proper. While efforts were made to increase spiegeleisen consumption during the war, owing to it being possible to manufacture this alloy from domestic ores, it is probable that the tendency to utilize only high-grade ferro alloys will now reassert itself, especially for the manufacture of mild steel, as spiegeleisen introduces too much carbon. The average recovery of manganese in making spiegeleisen is only 60%, as compared with 70 to 75% when making ferro-manganese. It is interesting to note that 1/6th of the loss goes to the stack and 5/6ths to the slag in spiegeleisen manufacture, while the losses are equally divided in making 80% ferro-manganese.

Chapter 9 deals with the national importance of allocating low-ash coke to manganese alloy furnaces, and points out that silica in fuel employed in making ferroalloys produces a greater loss than when smelting pig iron, as in reducing manganese ores the slag loss is in proportion to its volume. The review of the situation makes it clear that if the purer coke were allocated to furnaces manufacturing ferro alloys a great saving of manganese would be effected.

Chapter 10 discusses the electric smelting of domestic manganese ores. In order to determine experimentally if the low-grade domestic silicious, phosphoric, and ferruginous manganese ores, not amenable to ordinary methods of gravity concentration, could be used for ferro-alloy manufacture, a number of charges were worked in a small 65 kw. furnace.

In dealing with mineral containing more than 25% silica, it was found that an acid slag contained less manganese than a basic one. Dephosphorization was carried out as in the Jones process by concentrating most of the phosphorus in an alloy, and the manganese in slag, which was subsequently reduced with the production of a ferro alloy reasonably low in phosphorus, and with a 60% manganese recovery. Experiments on the ferruginous Cuyana ores by this process are also said to have been satisfactory. These results are not, however, of immediate interest, as only very exceptional circumstances would justify the electric smelting of such low-grade ores.

A number of electric furnaces producing ferro-manganese were operated in the United States during the war on a commercial scale, and others were in construction when the fall in prices, following the Armistice, brought about a suspension of operations. Particulars are given of the furnaces operated which, using the domestic manganese ores containing 15 to 25% of silica, produced an 85% ferro-manganese, with a recovery of 70 to 80%, which compares favourably with that of the blast-furnace. The power consumption was 5,000 kw. hours, and the coke used ranged from 1,400 to 1,200 lb. per ton of alloy in a 3,000 kw. furnace.

There is some difference of opinion regarding the most useful size of furnace. One operator maintains that a furnace with 1,150 kw. capacity has a recovery of 90% when producing six tons per day of 80% ferro-manganese; while for a 2,250 kw. furnace the recovery is only 70% with a production of 8 to 10 tons of alloy per day. It is found that the manganese stack-loss in the electric furnace is lower, and the slag loss about the same as when reducing manganese ore in the blast-furnace.

Figures are given, based on commercial practice and experimental work, of the estimated cost of producing 80% alloy in the electric furnace. Using domestic mineral containing 40 to 42% manganese and 13 to 20% silica, there should be a recovery of 72 to 75% of manganese with a 12% loss in the slag. In a 3,000 kw. furnace the power consumption would be 5,000 to 5,500 kw. hours; 153 lb. of electrodes and 1,800 to 1,900 lb. of coke would be used, with a production of 10 to 11·7 tons of 80% alloy per day. Better results would no doubt be obtained with mineral of higher grade from foreign sources.

The conclusion arrived at is that, while in normal times it would not be profitable to smelt manganese ore electrically in the United States, it might be done during a period of industrial activity or national stress. If it were possible to obtain water power at a very low rate, say 0·25d. per unit, in the vicinity of some of the foreign high-grade deposits, it is probable that electric smelting would be successful, and it is interesting to note that the Brazilian Government has recently decided to reduce the export taxes on manganese ore to any operator who undertakes to smelt electrically in Brazil 10% of his output of ore.

Chapter 11 is the report on the use of manganese alloy in open-hearth steel practice, and it is pointed out that manganese is not an ex-

pedient, but a basic requirement of successful practice in making steel. The principal function of manganese is to reduce ferrous oxide in the bath, and for this 0·35% manganese might be required. Manganese also eliminates sulphur and improves the rolling properties of the steel, as well as retards coalescence of grain growth, which would require 0·35%. It is also necessary to produce certain physical and mechanical properties of steel, so that the total consumption may be put at about 1 to 1¼% per ton of steel produced. Other deoxidizers, as silicon and aluminium, have a tendency to cause inclusions in steel, and they also encourage grain growth and leave the metal in poor condition for rolling and forging.

In order to reduce the consumption of manganese, the following recommendations to steel manufacturers were made: (*a*) Use of molten spiegel mixture; (*b*) high residual manganese in the bath; (*c*) use of silico-manganese alloy in place of the 80% material. All of these expedients are in use both in Europe and the States, in a limited degree. It is pointed out that the first cannot become general owing to the introduction of too much carbon for mild steel. The high residual manganese in the bath does not reduce consumption, except as it enables low-grade manganese ores to be used in making the pig iron. The use of manganese-silicon alloys is governed by the amount of silicon that can be tolerated in the steel, as it is prejudicial in material which must be welded, as well as for sheets and plates. In acid steel practice figures are given which show the consumption of manganese and silicon to be smaller, when introduced as silico-manganese, than when used as ferro-manganese and ferro-silicon; while for basic open-hearth practice results obtained suggest that the use of silico-manganese protects manganese in "oxidized" heats. It is probable that the use of this alloy will become more general.

In conclusion it may be stated that while the extreme shortage, and high price, of manganese ore during the war was a powerful incentive in the search for new supplies of high-grade ore, none appears to have been found, as the West African and Sinai deposits, now regular producers, were pre-war discoveries.

Further, efforts were made during the war, more especially by steel manufacturers of the Central Powers, to find some equally efficient substitute for manganese, without success. It is evident, therefore, that the future of the already known deposits, and the manufacture of ferro-manganese, are assured. American makers of ferro alloys are endeavouring to obtain tariff protection against the British product, and if successful, it is probable that future exports of ferro-manganese from this country to the United States will be smaller than in the pre-war period.

HERBERT K. SCOTT.

NEWS LETTERS.

TORONTO.

March 10.

MINERAL PRODUCTION OF CANADA.—The preliminary report on the mineral production of Canada during the calendar year 1920, issued by the Department of Mines, gives the total value as $217,775,080, which establishes a new high record. Compared with the production in 1919, valued at $176,686,390, an increase of 23·3% is shown. The metallic output was valued at $77,236,370, the quantities and values of the principal items being as follow: Gold, 766,912 oz., $15,853,478; silver, 12,793,541 oz., $12,908,683; copper, 81,155,360 lb., $14,166,479; nickel, 61,136,493 lb., $24,454,597; lead, 33,985,974 lb., $3,038,346; zinc, 40,166,200 lb., $3,081,149; cobalt, 593,920 lb., $1,484,800; and pig iron from Canadian ore, 75,869 tons, $2,066,997. There was a noteworthy increase in the production of coal, which amounted to 16,623,598 tons valued at $77,326,853, being 21·5% in quantity and 42% in value in excess of the output of 1919.

PORCUPINE.—There has been a further curtailment in the allotment of electric power to the producing companies. The Hollinger Consolidated is now only getting 1,500 kilowatts, as compared with its full requirements of approximately 10,000. By the use of its steam auxiliary equipment it is able to continue work at about one-third capacity, treating about 1,300 tons of ore per day at an extra cost of about $900 daily. The company has entered an action for damages against the Northern Canada Power Co., Ltd., on account of losses sustained by reason of power shortage, the outcome of which will be of much interest to mining operators whose business has suffered from the same cause. The annual statement of the Hollinger Consolidated for 1920 indicates that, despite all drawbacks, the company has had a prosperous year. Its total revenue was $7,162,611, as compared with $7,063,099 in 1919, and the net profit was $2,675,274, as against $2,321,290. The sum of $461,274 was added to the surplus, bringing the total up to $6,462,918. The net yield of ore treated per ton was $9·56, as compared with $9·40, and the value of the ore reserves

was estimated at $36,596,059, as compared with $39,928,430. During 1920 the Dome Mines treated 295,220 tons of ore, the yield from which amounted to $2,005,640, an average extraction of $6·80 per ton. In addition the company received about $200,000 exchange premium, which would bring the average yield up to about $7·50 per ton. The McIntyre has been encouraged by the development of a large ore-body, believed to come in from the Hollinger, on the 1,000 ft. level, to plan an increase in its milling equipment, augmenting its present capacity of 600 tons to about 900 tons, which, according to an estimate based on last year's figures, would give an annual production of $3,000,000. The additional crushing and grinding machinery has been ordered and will be installed as early as possible. The McIntyre has secured power rights at Sturgeon Falls on the Mattagami River, 30 miles from the mine, capable of generating 9,000 h.p. Unless the power company can increase the supply of electric energy sufficiently to prevent a repetition of the shortage now experienced, the McIntyre will generate its own supply. The coming season promises to be a very active one. Labour is plentiful and efficient, and as soon as the spring has fairly set in work will be resumed on many prospects and new enterprises will be undertaken.

KIRKLAND LAKE.—The annual statement of the Lake Shore for the year ended November 30, 1920, showed an income of $528,028, the net amount carried forward after all deductions being $104,992. During January the production was valued at $37,375 from the treatment of 1,674 tons of ore, the extraction averaging $22·34 per ton, the mill running 82% of the possible time. A station has been cut at the 600 ft. level, at which lateral work is in progress. At the Wright-Hargreaves the new mill of 180 tons capacity is ready for operation, but it will not be started until May 1, by which date a full supply of power is assured. A 4 ft. vein of high-grade ore has been encountered on the 700 ft. level of the Kirkland Lake mine.

COBALT. — The silver-mining industry is much depressed owing to the low price of silver, coupled with power shortage, and it is somewhat doubtful whether many of the mines which closed down over the winter will be reopened until market conditions show improvement. The Mining Corporation of Canada has closed down its mines and mills indefinitely, and will make extensive alterations in its concentrating and cyanide plants so as to be in a position to handle an increased tonnage at lower cost when work is resumed. The company is the second largest silver-producer in Canada, its output last year being 1,806,274 oz. of silver. The Moore Filter Co., of New York, has brought an action against the Nipissing Mining Co., claiming $600,000 damages for the infringement of their patent rights in the filter used for the filtration of metal-bearing slimes. The Oxford Cobalt will shortly resume operations. The shaft will be put down from 180 to 350 ft., at which level a cross-cut will be run to tap the vein. The Chambers-Ferland has opened up at the 410 ft. level a rich vein 2 in. wide coming in from the Nipissing, which in some places yields ore carrying 5,000 oz. to the ton.

SUDBURY.—The mine and smelters of the British American Nickel Corporation have been closed down owing to unfavourable market conditions, throwing 600 or 800 men out of employment. Only a small nucleus of the force has been retained, so that when a change for the better occurs production can be resumed at short notice. The refinery of the company at Deschenes, Quebec, employing 400 men, will also close shortly. The company was a war enterprise, started in 1916, in which the British Government was heavily interested. The Mond Nickel Co. has reduced the wages of their employees 40 cents per day.

VANCOUVER, B.C.

March 1.

SHEEP CREEK.—With the gradual decrease in the cost of labour and supplies, and with the general slump in base-metal mining in this Province, mining men seem to be turning their attention, once again, toward gold-mining. An important deal that has taken place within the last few weeks is the bonding of the Queen mine, at Sheep Creek, near Nelson, to C. H. Cassill, of Spokane. The people of Spokane, it may be said in passing, take a far more active interest in and derive a greater benefit from the mining industry of British Columbia than the people of any city in the Province. Some of the biggest and best paying mining enterprises in the Province were started in Spokane. The Queen mine was located towards the close of last century, and mining operations were carried on busily until 1915, when a cave in the main winze caused the closing of the mine. Up to this point the mine had produced more than one and a half million dollars in gold. The mine remained closed until the end of the war. In 1919 it was bonded to A. W. McCune, the well-known Butte operator, and a long tunnel was driven. The result of the work, however, was inconclusive; gold-mining generally was very

much in the doldrums at the time, so the work was abandoned. In the meantime, C. H. Cassill had bonded the Ore Hill group, which adjoins the Queen, and on it had developed a strong vein over a distance of more than 2,000 ft. This vein has all the characteristics of the Queen vein, and the trend of the strike is in a direction that led Mr. Cassill to suppose it was the same vein. He, therefore, obtained a short option on the Queen, had it examined by J. C. Haas, of Spokane, and the present bond and lease, which will expire on July 1, 1923, has resulted. On the bottom, or 700 ft. level, the vein is exposed over a distance of 800 ft., is from 8 to 33 ft. wide, and is said to have an average value of $9 per ton in gold. There is a 20-stamp mill on the property, and ample water rights on Sheep and Wolf creeks go with it. The flume and the mill, after a period of six years' idleness, will necessarily need considerable repair. Mr. Cassill proposes to combine the two properties, the Queen and the Ore Hill, and float a company to be known as the Queen-Ore Hill Mines, Ltd., with a capital of $250,000, which is the actual price he is paying for the two properties.

GRANBY CONSOLIDATED.—The Granby Consolidated Mining Smelting & Power Company got all the best of its two appeals against the Esquimalt and Nanaimo Railway for title to the Cassidy Colliery coal areas, on Vancouver Island. The Granby was given full title to the Dunlop property, and the Court found that title to the Ganner property was vested in the Granby Company, but in case of assessment for damages in respect to the coal-rights these were to be considered as "coal in nature." The outside price at this rate is stated to be $150 per acre for the 200 acres involved, so the utmost that the Granby can be called upon to pay is $30,000. When it is remembered that the Granby has expended more than $2,600,000 in the purchase of the property, purchase of timber rights in connection with it, and in the equipment of the colliery and building of the town, to which must be added another $2,000,000 for the building of the by-product coke ovens, at Anyox, to carbonize the coal, the present liability is comparatively small. The counsel for the E. & N. Ry. gave notice of appeal to the Privy Council, and, pending the result of this appeal, the Granby has been given the right to continue mining coal from the property. E. E. Campbell, assistant manager, and for many years in the employ of the Granby, has retired to become general superintendent for the United Verde Extension Mining Co., at Jerome, Arizona, and J. A. Bancroft, professor of geology at McGill University, has been appointed in his place. Prof. Bancroft will take up his new duties at the close of the present university term. Granby is doing some excellent work; it is producing more copper and at a cheaper rate than at any time since the armistice; in fact, it is claimed that, but for the interest on its bonded indebtedness, Granby would be producing more cheaply than any concern on the continent. With the exception of an insignificant amount from the Rossland mines, and a small amount from the Belmont-Surf Inlet mine, Granby is the only concern producing copper in the Province.

MISCELLANEOUS MINING NEWS.—The Consolidated Mining & Smelting Company is maintaining an excellent production from its own mines, principally the Sullivan. The first six weeks' ore receipts at the Trail smelter amounted to nearly 50,000 tons, which is about 8,000 tons more than the quantity received over the same period of last year. With the exception of a little more than 1,000 tons, this has all come from the company's own mines. Owing to the fact that the company during the slump in the prices of lead and zinc is paying only in warehouse receipts, few concerns are financially able to ship ore to Trail. In fact, the mines in those districts that have been relying on the Consolidated company to treat their ores are nearly all closed. The Florence Silver Mining Co. is proposing to put a steamer and barges on Kootenay lake, thus enabling it to ship concentrate to Five Points, and thence by the Great Northern to either Northport or Kellogg, in the United States. This would render it independent of the Canadian Pacific Railway, for which company few of the mine-owners have a good word to say. It is likely that the Bluebell Mining Co. will follow the same course. The Slocan and Slocan City mines are not so fortunately situated geographically.

The Belmont-Surf Inlet Mines, Ltd., a subsidiary of the Tonopah-Belmont Development Co., continues to give a good account of itself. The net earnings for the quarter ended September 30 was $68,640, and was the principal source of income to the parent company. The gold, which is the principal product, is collected with the silver and copper in the form of a concentrate that is shipped to the Tacoma smelter.

Since the closing of the Nickel Plate mine, at Hedley, last fall, T. Griffin has been exploring his property near the Nickel Plate, and has developed a lode some 100 ft. in width, the whole of which is said to be shipping ore. A trial shipment is being prepared, but, owing to the position of the property, high up on the

mountain side, considerable trail building will be necessary before ore can be taken from the property.

The discovery of a deposit containing strontianite and celestite is reported from Princeton, and at the present time is being explored with a view to recovery of the minerals on a commercial scale.

OIL.—The Imperial Oil Company has shipped an extra heavy drilling outfit, capable of boring 4,000 ft., to Pounce Coupe, which is situated in the Peace River Block, a national forest reserve, the oil-rights of which are vested in the Dominion Government, although it is situated within the boundary of British Columbia. Oil seepages have been noted along the banks of the Pounce Coupe river, a tributary of the Peace river.

C. M. Rolston, local manager for the Imperial Oil Company, has announced that arrangements have been made with California producers for the delivery of 600,000 barrels of oil during the present year; consequently, it is likely that the company's refinery, at Ioco, near Vancouver, which was closed last fall, owing to inability to get crude oil, will be re-opened shortly. It was expected that the refinery would be closed until June, when arrangements had been made for a supply of crude oil from Mexico.

KALGOORLIE, W.A.

February 21.

MINING CONDITIONS IN WEST AUSTRALIA.—In many country cemeteries one sees recorded on a tombstone a verse which relates that the deceased was troubled sorely with affliction for a very long time, in spite of the efforts of his physicians. For over thirty years the mining industry in this State has suffered many afflictions, of which the greatest has been the promotion of wild-cat companies, due to the inherent desire of mankind for a gamble. Unfortunately too often "the cards have been stacked," so that people in all good faith put money into companies, accepting the opinion of men who had not the training nor experience necessary to size up the possibilities (if any) of the property on which they were paid to report. The trail of the feline, which started at the Coolgardie boom, followed at intervals at Kalgoorlie, Bullfinch, and quite recently at Hampton Plains and Mt. Monger, has drawn attention to the worst aspect of mining and detracted from the good work done on the producing mines.

The most recent affliction and one that threatens to kill the industry is the award of the Arbitration Court given at Kalgoorlie. The miners themselves never expected to receive a minimum wage of 16s. per day. The other penalties on the industry, including the fortnight's holiday each year on full pay and overtime rates, amount to so much that the border-line between profit and loss has now been crossed by several of the mines on their previous ore-reserve average. The result is that the grade has to be increased, where possible, which means the earlier demise of the mine, or where it is not possible to do this operations must cease.

A statement frequently made by trades unionists, even by Presidents of Arbitration Courts throughout Australia, is that if an industry or a mine cannot afford to pay a living wage (a term which is too variable to define) it is better for that industry or mine to shut down. That at first sight seems sound, but the point is that the employers realize the economy of paying a good man a high rate of wage, if he will produce a profit on that wage by work done, and the more men he employs on contract who can and do earn above the current wage, the cheaper are his costs, up to a limit. However, what he does object to is the payment of men who will not, or cannot, produce the value of the minimum rate of wages which they demand, and by the award of the Arbitration Court must now be paid. In a small mine, men can be picked and those who will not do their bit are weeded out, but when it comes to employing a large number there is an increased proportion of those whose work results in a dead loss to the employer. During the war the pick of the mine employees enlisted; the older miners could not maintain the average, while those who did not enlist were, as a general rule, the least willing workers. This has meant a general decrease in efficiency per man and consequent increase in the cost per ton. Since the Lancefield and Sons of Gwalia have ceased operations (to which reference will be made later on) a great many good men from these fields have moved into Kalgoorlie to look for work. The managers there can now replace the red raggers who will not work for these men who are anxious to make good money on contract. For some years past, on some of the big mines, the supply of ore in the bins on Saturday night has been hardly sufficient to keep the mills going until Monday morning. The advent of a more plentiful supply of men from the above mines has relieved the position considerably in this respect. Thus the mines which can survive the transition period will no doubt last for some time longer, at the sacrifice

of others whose reserves are too low in grade to pay the high wages, together with post-war prices for stores and machinery spares.

LANCEFIELD. The Lancefield mine, which has been ably handled by a small company, whose shareholders are themselves mining engineers, has had to shut down, because the margin of profit has been cut out by the award. Before doing so, Mr. Ridgeway, managing director, called a meeting of the employees, and made them an exceptionally generous offer to take over the mine and mill, on a nominal tribute of 1s. per ton crushed, on condition that the manager was nominated by the company. The latter offered to finance the scheme until returns were available. On the advice of the Labour Union representatives, the offer was turned down, almost without discussion. This is an answer to the labour leaders who in times of stress suggest taking over the mines, to show how they could be run by miners. They evidently realize that the mine-owners' profits are not so great as they would believe, or are frightened to take the risk which they expect the company to do of making it pay. There is no question as to the amount of ore available, so it is not a matter of having to develop it before they can mine it.

SONS OF GWALIA.—The Sons of Gwalia, after a career of many years as the biggest gold producer outside of Kalgoorlie, has had the misfortune to have its power and crushing plants destroyed by fire. It is now a question for the directors to decide upon the size of a new plant which is warranted, and also how long it will be before it can be erected. Meantime hundreds of men are out of work, and the whole town of Leonora is indirectly affected. The Minister for Mines is endeavouring to arrange some scheme whereby a number of these men can reopen abandoned mines in the district, possibly with the active help of the Gwalia Company, and crush the ore at the State Battery under a board of supervisors. It is an experiment which will be watched with interest, and its success will depend upon the amount of co-operative effort put into it by the workers, rather than on any artificial spoon-feeding by the Government.

STATE AID FOR PROSPECTORS.—The Minister for Mines has made a proposal to subsidize prospectors to the extent of 70s. per week per man, but as it has been pointed out by those who have taken an interest in this work, all the easily found lodes and deposits in West Australia have been discovered, and if any subsidized prospecting is to be a success, it must be under the supervision of a mining geologist. It is not only a question of systematized information, which the geologist has to blend with the practical knowledge of the prospector. It is the economic reason that, if the State pays the prospector wages, it must see that his work is carried out to the best advantage.

HAMPTON PLAINS.—At Hampton Plains work is now mainly confined to the development of those mines on which payable ore has been found. On the Celebration, after some delay in the supply and erection of the winding and compressing plants, the main shaft is now 210 ft. down in very hard country. The sponsors of this property are still sanguine that, while the lode was poor at the 193 ft. level, the value of the ore will improve when it is cut in settled country. It will not be long before the shaft reaches a depth of 300 ft., when the question will be settled.

On Lease 81, which is on ground reserved by the Hampton Properties Company, the Celebration lode has been found carrying good prospects, and a shaft is being sunk to test it at depth. The same company is sinking two shafts on a lode on Block 45, which lies several miles to the east of the Celebration. At a depth of 50 ft. the lode in one shaft averages 1 oz. per ton over 6 ft., and in another 75 ft. along the line of lode averages 15 dwt. per ton over 8 ft. in width. Although this belt of country is typical of the Golden Ridge series of lodes, it appeals more to a mining man than the more porphyritic country on Block 50. The Boulder No. 1 Company had an option on an adjoining lease, but the lode they prospected, and considered not good enough, was on a different line from that described above. On Block 48, the Golden Hope winding and pumping plant is now being erected, and as the railway line has reached this property, the company expects that it will shortly be able to send in regular consignments of ore to Kalgoorlie to be treated.

On the White Hope mine, the lode consists of hard sulphide ore, and the development work, which is necessarily slow, has so far not revealed any long shoots.

The Hampton Areas Company is having a geological survey of its blocks made by its resident manager, and as a result of his work it is quite possible that some new lodes may be found to be worth development. By referring to the map published in the MAGAZINE in October, 1919, it will be seen that the Hampton Properties and Areas companies hold blocks of land spread over a width of 30 miles, in which there is a lot of greenstone country, which has not yet been systematically prospected.

MOUNT MONGER.—Out of the dozens of companies floated and hundreds of mining leases taken up at Mount Monger during the recent boom, there have only been a few small crushings of rich patches of ore. One from the Prospector's (McCahon's) Mine of 38 tons was treated at Kalgoorlie last week for a return of 886 oz. of gold, and the tailing is expected to add another 200 oz., which will mean an average return of about £150 per ton. This ore was picked from a dump of 200 tons the balance of which is estimated to be worth 1 oz. to the ton.

The Monger Proprietary is the next mine to this, and has the surface portion of this pipe of rich ore now being developed. The Lass O'Gowrie lease, which was the cause of the rush to the field, and on which an option was taken at a very big price, has been dropped by the option-holders, and the company has gone into liquidation. With a well-known mining engineer, I made an inspection of this field a year ago, and while the prospector (McCahon) invited us to sample and see his workings, the owner of the Lass O'Gowrie refused us permission to make even a cursory inspection of his show. It has been my experience, in this State at any rate, that if a prospector has anything good he is willing to let a mining engineer inspect it; on the other hand, a refusal makes one doubtful of the value of the find.

RAVENSTHORPE.—At Ravensthorpe, mining is also at a low ebb. Not that there are no mines worth operating, but no improvement can be expected until some better means are devised for concentrating the lower-grade copper ore, so that the Government smelting works will not have to rely on high-grade ore alone, as at present. The supplies of the latter are not sufficient to keep the furnace going. Consequently the costs are higher than the industry can stand, with the present low price of copper. It is possible that if the Government were to put up a mechanical concentrator for the roughs, and a flotation unit to treat the finer sulphides, to be run in connection with the smelter, the whole of the ore, which is at present picked, could be mined and treated at a profit.

OIL.—During the stay of the Agent General in the State, several speculators, who believe that oil may be found near the south coast of West Australia, have met and given him their views on the matter, so that when he returns to England, almost immediately, he will be able to discuss the question with some firms who are anxious to prospect for oil. The Government Geologist, on the other hand, does not class any of that country as likely to be oil-bearing.

MELBOURNE.

February 1.

HYDRO-ELECTRIC POWER IN TASMANIA.—The sixth annual report of the Tasmanian Government Hydro-Electric Department gives a large amount of interesting information relating to the progress of the work undertaken by this public enterprise. An active policy of development is being carried out, although operations have been severely retarded owing to the conditions created by the war, and by industrial unrest. The shortage of cement in particular has seriously delayed the progress of the work of constructing the Great Lake dam, while the date of erecting pipe-lines and other equipment will be fixed by the time when cement supplies become available. Five new turbines and alternators, together with switch-gear and apparatus, are on order, but the work of completing the power station is being done in stages owing to the shortage of labour and cement. The excavations for the whole extensions are well in hand, and concreting has been commenced on that portion of the extension required to accommodate one unit.

The position of a new transmission line, running south, has been fixed, and most of the necessary towers have been ordered. This line will continue on the eastern side of the River Derwent to Risdon, instead of crossing at Bridgewater, as it was not found practicable to effect another crossing at this point. It is probable that as soon as the new transmission line is in service the existing line between Bridgewater and Hobart substations will be dismantled and re-erected along the same route on the eastern shore of the Derwent, thus considerably reducing maintenance costs. The completed transmission line will include four district circuits, one of which may be shut down from time to time for inspection and repair. The Launceston transmission line has been located, and a good start has been made towards clearing the route. The surveys did not disclose as good conditions from a wood-pole point of view as were hoped for, and the increasing cost of labour and insulators made it desirable to carefully investigate the question of whether a steel tower line would not, in the end, be more economical. Tenders have been called for the construction of towers, and when offers are received a decision will be arrived at as to whether wood or steel is most suitable material for the construction. It is

anticipated that the Launceston service can be given in about 18 months' time.

The necessary machinery for the Risdon substation is on order. At this substation the whole of the high-tension apparatus will be out of doors, only the low-tension switching, measuring, and repairing apparatus being under cover. The necessity for the Risdon substation being established to supply the Electrolytic Zinc Co., has made it desirable, in the interests of economy of operation, to make this the substation to supply Hobart, instead of the substation at present at New Town. This will be arranged for by taking up the supply of the first block of power to the Zinc Co. at Risdon, as soon as it is completed, then removing the outdoor portion of the present Hobart substation to Risdon, and taking up the Hobart supply with that; leaving the present indoor portion of the Hobart substation available for other use. It is intended to dismantle and re-erect this portion at Launceston in time to take up the supply of power to that city when required. Arrangements have been made to carry a high-tension line from Risdon substation to the present Hobart substation site to connect on to the Electrona transmission line extension, and this new interconnector will be used in the first instance to feed the Risdon substation. The machinery required for duplicating the Electrona substation has arrived, and will be erected at an early date. This will bring the capacity of this substation up to 8,000 k.v.a. Great difficulties were encountered in finding a suitable site for the new Arthur's Lakes dam. Tests pits that were sunk revealed porous country, but a suitable site has now been found, and tenders are being called for the construction of an earth-filled dam, which it is hoped can be completed during the coming summer. The steadily increasing cost of labour, without a corresponding improvement in the output per man on hand-work, is still a source of considerable anxiety. The basic wage at the Great Lake, at Liawenee, is 14s. per day, and 13s. 4d. per day at Waddamana, as compared with the average basic wage of 8s. 6d. per day when the work was first started. The high rate of exchange with America and the Customs duties on imported plant are also influences that have a severe effect on increasing construction costs.

The officers of the department are engaged in water-power surveys in various parts of Southern Tasmania, and the report shows what has been done on the Shannon, Little Pine, Ouse, Derwent, Styx, and Huon rivers and the Rolliston scheme. Surveys have been completed for the proposed scheme of the Huon river, and plans and estimates are being prepared. The proposed works include a dam 150 ft. high, flooding about nine square miles of land surface, and the power available will be about 20,000 b.h.p. The larger tributaries of the Huon are now being investigated. The surveys of the Rolliston scheme have also been completed, and this entails linking up several small catchments by means of races and a tunnel giving a total catchment of about 27 square miles. Four storage reservoirs will be provided by constructing dams across the Anthony river, Newton Falls, and Julia Creeks. The pipe-lines will consist of a 6 ft. diameter wood pipe, 12,000 ft. long, feeding two 48 in. steel pipes. The head available is 1,130 static, which gives about 22,000 b.h.p. catchment available at turbine shaft. The Styx river has long been regarded as the source from which Hobart's water supply must in the near future be augmented, but a further investigation has proved conclusively by exploration that no storage approaching suitable size exists here, and therefore any scheme must be based on minimum flow and auxiliary plant. The minimum flow is about 25 cu. ft. per second. A fall of about 500 ft. can be obtained by a diversion of the river into Park Rivulet, but the output for minimum flow would only be 1,000 b.h.p. The feasibility of diverting the Styx river into the Plenty catchment is now being investigated, and it has been discovered that a basin suitable for storage purposes exists at about 700 ft. above sea level. Some large storage is essential in order to equalize the flow, and unless this can be made available economically there is no future for the Styx catchment as regards power.

NORTH OF ENGLAND.

We are now well into 1921, and there has been no indication of any improvement in the metal position. Lead and zinc have reached a level that roughly corresponds with that of 1914, but the value of concentrates is of course relatively lower. Galena of 80% Pb is worth about £8, while lead is £19, but blende is really unsaleable. I saw one formula offered recently which gave a *minus* value of 23s. 6d. per ton for 50% ore, with spelter at £25. In this case the formula gave a considerable improvement with spelter at, say, £40, and at that level most mines would be able to produce. The smelters do not think that lead can remain at anything like the present low price and there is a certainty of an appreciation. It is, how-

ever, impossible to anticipate when this will occur, and mine managers tell me that they cannot work with lead at under £35. This of course implies the existing ratio of cost. A permanent recovery depends largely on coal. A substantially lower price for coal would affect the mines immediately in two directions, that is, the actual cost of fuel, and the lower returning charge payable to the smelters. The first reduces the cost of production; the second raises the value of the concentrates. But with the present coal strike it is impossible to look far ahead at present. The principal factor is, however, labour, and recently there has been a more striking alteration in the attitude of the Union leaders. Up to recently the men have been under the impression that the owners had some inexhaustible reserve from which to draw, and that wages could be paid whatever the price of concentrates. They now see the results of their demands, in the virtual suspension of the lead industry, and they realize that their members are out of employment, with but little hope of re-engagement. I suppose that the whole situation has been carefully considered, as the owners are now, for the first time, receiving the active co-operation of the Union in the reinstatement of the industry. It is realized that wages must come down, and that no longer can the men be transferred to more lucrative employment, that half a loaf is better than no bread, and that it is now a case of saving the ship. Several instances have come to my notice that confirm this, where the Union officials have unhesitatingly accepted the principle of lower wages, on the grounds that wages can only be payable out of production, and that the "cost of living, with an improvement in the standard of life" basis, must be abandoned for the moment.

The officials of one of the largest unions connected with our industry came down to a local mine, and, quite frankly, advised the men to accept a large reduction in wages, and indeed to accept the principle of a minimum wage on a really low basis, if the company would devise some system by which an automatic rise in wages would take effect when prices improved and the cost of production became lower. He pointed out to the men the importance of reducing costs in every direction, *by better work*, and stated that the "ca' canny" idea was suicidal. The management was much impressed by this new attitude, and agreed to consider a scheme of the nature indicated.

Managers must not altogether found their hopes on a rise in prices; they must concentrate on reducing the cost of production. Too often this is confined to the idea of better mechanical methods, involving heavy capital expenditure, but I venture to submit that it is far more important to reorganize the system of employment, and to get the men really interested in their work. The potential savings in this direction are enormous. As an illustration which shows the margin of saving, I may instance what occurred recently in a large mine. The contracts were cut 20%, and in the next succeeding pay, the average daily wage was as high as the previous month. Labour conditions and labour ideals must now be studied as an essential part of mine management, and I believe that with these satisfied, the cost of production can be enormously reduced.

The Mine Owners' Association met in London recently, and there was naturally a feeling of intense depression, some members even going as far as to suggest that the Association should be disbanded, but this was promptly overruled. This year will undoubtedly be the worst that has ever been experienced, and it is more than ever important to stick together. Many of the members feel that there should be co-operative selling of concentrates, and at the meeting in June a scheme may be brought forward. A large buyer of blende told me that he would not entertain buying small parcels, and pressed upon me the importance of offering a continued output. The Swansea smelters have always stated that if they had a substantial supply of blende, they would gladly give a higher price. They want security for raw material, and little odd lots are obviously no good to them. The same rule applies to galena, and if even a proportion of the mines combine, it would be to the advantage of both the owners and the smelters. A meeting of the Industrial Council was held the same afternoon, and the Union members showed a spirit of co-operation that certainly was an immense encouragement to the owners. It was the best meeting that we have held, and will lead to great things if we can continue to look upon the industry as a joint interest of men and owners. The names of Mr. Anthony Wilson and Mr. J. L. Francis were suggested to act as owners' representatives on the Board of Trade Consultative Committee for Non-Ferrous Mines. I hear that Mr. Bridgeman has asked Mr. Wilson to undertake this duty, and that Mr. James Wignall, M.P., has been appointed to the Committee to represent the labour side.

As to the mines themselves, they are practically all stopped or stopping. At Thornthwaite the mine is being kept clear of water, and two ends are being driven, the directors having decided to continue this small programme in the

hope of better prices, failing which the mine will be dismantled. Threlkeld mine is now stopped as a producer, and all the men have been dismissed, except 10, who are engaged in carrying through a ventilation level. There are happily no pumping charges, and the mine will re-start directly prices improve. There has been a general reduction of 12s. per week at both these mines, and the men have expressed a general desire to start work directly there is any substantial improvement in the value of concentrates. At Greenside mine the liquidation continues, and the lower rate of wages has been accepted, but unfortunately the drawing and dressing of the crude ore in stock has been suspended for the present. A higher price for galena will enable the work to be resumed, as there is still a large tonnage of broken ore to treat. I am afraid that the Vieille Montagne Zinc Co. have decided to permanently close down the mines in the Alston district. This is a great blow to the industry, their production of blende being by far the largest in the country. A small programme of development is being pursued, for this year, at Nentsbury mine, in the hope of finding new deposits; if successful it might affect the situation.

The position at Wanlockhead and Leadhills is critical. Despite all conciliatory influences, including, strange to say, a visit from Mr. Smillie, the men refuse to accept a reduction in wages. The cost of pumping at these two mines is approximately £3,000 per month, and unless the men agree promptly to a substantial reduction in wages, the mines will be flooded, which would mean the extinction of the industry in that area. I sincerely hope that the men will not persist in their unreasonable attitude, as a temporary period of low wages might carry the mines through the crisis, and they would then have the opportunity of participating in better times, if these come.

In the Weardale area, Boltsburn and Sedling mines are both working, but at a very large reduction in wages. I am glad to learn that the men accepted the necessary change in a most friendly spirit, and at lower wages they are putting increased energy into their work. The quarries in this valley are practically closed down for the present, as the products, ganister and limestone, are principally required for the iron and steel works in the Durham area. Lord Allendale's mines are still at work, and I understand look well. I hear that Mill Close mine in Derbyshire is still producing, and that the workings look very well, but I have no direct knowledge.

There are no mines producing in Wales. East Halkyn is closed down, and at the famous Halkyn mine I believe that one level is being driven. Continual negotiations are taking place over the tunnel scheme, but there seems no immediate probability of a settlement being reached. It is more than ever difficult to understand why all parties cannot sink differences and come to a working arrangement. The Shropshire mines are practically closed down for the present, but this is merely temporary, the demand for barytes being very poor just now.

I hear that the Swansea zinc smelters have by no means given up hope of a revival of this industry, and that some of the works are now engaged in repairs and improvements to the plant. The hope is that by the end of the year there will be much higher prices, and that lower costs will enable them to resume work. A small cargo of Australian zinc concentrates has been delivered at Antwerp at a freight charge of 45s.; with the original cost of £4. 10s. at Port Pirie, the cost, as far as these charges, would be £6. 15s. for 47% ore. I cannot learn that the Board of Trade has fixed any basis for the sale of their huge stocks of ore which still hang over the market.

PERSONAL.

The firm of PHILIP ARGALL & SONS, of Denver, has been dissolved.

RALPH ARNOLD has been on a short visit to London from the United States.

W. BARAGWANATH has been appointed Director of the Geological Survey of Victoria.

GEORGE BARGATE, late of Dolcoath, has been appointed superintendent for the Central European Mines, Ltd., Jugo-Slavia, for which Bewick, Moreing & Co. are the general managers.

JAMES P. BEST is returning from Nigeria.

EDGAR BONDS is expected from West Africa.

PROFESSOR J. S. S. BRAME has been elected president of the Institution of Petroleum Technologists.

A. R. CANNING has left for Nigeria.

W. A. CARLYLE has returned to London from Canada.

E. H. CLIFFORD has resigned as consulting engineer to the Central Mining and Investment Corporation.

J. A. DUNN, of the Bendigo Amalgamated Goldfields, has been elected to a Frecheville Research Scholarship at the Royal School of Mines. He is making a petrological study of the rocks at Mount Bischoff before coming to England.

J. C. FARRANT, London manager for the Hardinge Company, was married to Alice Christine Gaskell on April 7.

DR. J. S. FLETT has been elected president of the Geological Section of the British Association meeting to be held in September.

W. F. GARLAND has retired from the secretaryship of the Mysore Gold Mining Company after serving in that capacity for twenty years, and has been elected a member of the board.

W. H. GOODCHILD has gone to Spain.

S. V. GRIFFITH has joined the staff of the Corocoro United Copper Mines, Ltd., Bolivia.

A. A. HARRIS is back from Nigeria.

DR. F. H. HATCH has been appointed by the Secretary of Mines to be technical adviser to the department on questions relating to the metalliferous mining industry.

HYMAN HERMAN, engineer for briquetting for the Victorian Electricity Commission, is going to Germany to purchase briquetting plant for use at the Morwell brown coal deposits.

H. R. HILL has been appointed president of the Transvaal Mine Managers' Association.

ROSS B. HOFFMANN has returned to the United States.

J. VOLNEY LEWIS, head of the department of geology at Rutgers College, New Jersey, has been appointed first secretary to the Society of Economic Geologists, recently formed in America.

EDWIN LUDLOW is the new president of the American Institute of Mining and Metallurgical Engineers.

HAROLD D. MARTIN has returned from India.

E. P. MATHEWSON is here from the United States.

CAPTAIN A. H. MOREING is a member of the House of Commons Select Committee on Telephones.

H. L. MORTON has left for India to take up an appointment with the Bengal Iron Company.

EDGAR PAM has been appointed manager of the Modderfontein East.

G. S. PATERSON has returned from Peru, and has gone to South Africa.

W. PELLEW HARVEY has left for Australia.

J. S. PENBERTHY has joined the staff of La Compania Estanifera de Llallagua, Bolivia.

A. R. PENGILLY is now at Tampico, Mexico.

JOHN ROBERTS has gone to Mysore

E. G. ROBSON has gone to Venezuela.

HUGH ROSE is expected from Mexico.

R. A. RUSHA is expected from Nigeria.

HJALMAR E. SKOUGOR is here from New York.

DR. G. F. HERBERT SMITH has been appointed assistant secretary at the Natural History Museum, South Kensington.

DR. O. J. STANNARD has left on a short visit to the United States.

ARTHUR E. TAYLOR is on his way home from India.

J. B. TYRRELL is visiting the gas and oil regions of Alberta.

G. A. WATERMEYER, A.R.S.M., has been appointed professor of mining in University College, Johannesburg.

SIR TREVREDYN WYNNE has returned from Burma.

H. H. YUILL is back from West Africa.

W. E. THOMAS died last month from pneumonia.

S. R. BASTARD, director of several Nigerian tin companies, died last month.

D. T. WILLIAMS, a well known London analyst, previously connected with the South Wales metal industry, died last month.

HENRY BATTENS, lately manager of the Grenville mine, died last month. He was a Cornishman by birth and training. He spent many years in New Zealand, where he became manager of the Hauraki gold mine.

SIR ROBERT TAYLOR, head of the firm of John Taylor & Sons, died early this month. He was knighted last year in recognition of the firm's great services in connection with Indian mining.

The Mining World celebrated its fiftieth anniversary this month. We wish Mr. W. CHISHOLM, the proprietor and editor, many more years of prosperity.

TRADE PARAGRAPHS

THE GLOBE PNEUMATIC ENGINEERING CO., LTD., of 1, Victoria Street, London, S.W.1, and Luton, send us their new catalogue of pneumatic tools, including hand hammer-drills and rivetters

METROPOLITAN-VICKERS ELECTRICAL CO., LTD., of Manchester and Westminster, send us leaflets relating to three-phase transformers for rotary converters and transformers for use in collieries.

EDGAR ALLEN & CO., LTD, Imperial Steel Works, Sheffield, send us their *Edgar Allen News* for March. This contains notes on the application of magnetite for iron and steel making and the prevention of fitchering of drill steels.

THE GENERAL ELECTRIC COMPANY, LTD., announce their approaching removal to a new building erected for them in Kingsway, London, W C.2, and named Magnet House. The show-rooms will remain at Queen Victoria Street. They also send us their circular O.S. 2465 relating to their Osram miners' hand lamp.

VICKERS PETTERS, LTD., of Ipswich, send us an elaborate catalogue relating to their Semi-Diesel Crude Oil Stationary and Marine Engines. Among the novel features may be mentioned the new electrical starting apparatus. The London offices of this company are being moved from Great Portland Street to 75b, Queen Victoria Street.

THE MOND NICKEL CO., LTD., have been giving cinematograph shows at their offices, 39, Victoria Street, Westminster, illustrating the operations at their Sudbury mines and at the Coniston smelters. Mr. Robert Mond, Chairman of the company, kindly gave most interesting descriptions of the work done and of the business of the company when a special show was given to representatives of the press.

METAL MARKETS

COPPER.—Although early in March the market was easy, in the latter part of the month things took rather a firmer turn, this remark applying to both standard and refined metal Some purchases of standard were entered into some time ago on American account, and because there were fears that the warrants might be taken up when such contracts matured, and as there is comparatively little rough copper in store, bears became rather anxious to cover their open positions and a good demand ensued for intermediate dates The result has been that standard copper values came very close to those of refined. Latterly a more hopeful feeling was engendered in the general situation by the reports of further curtailment in America. It is understood that not less than ten producing companies are ceasing production, including Anaconda, Utah, Ray Consolidated, Chino, and Nevada Consolidated. It is not surprising that producers have got tired of turning out their copper at a loss, and this rather drastic cut in production should eventually improve the situation. Meantime there are still the very large accumulations on hand to be disposed of. It seems that in spite of recent curtailments production continued in excess of consumption, and that the accumulated stocks have increased considerably since the end of the year. Consumption everywhere is unsatisfactory.

Average price of cash standard copper: March 1921, £67. 13s. 3d.; February 1921, £71 0s. 9d.; March 1920, £109. 11s. 10d.; February 1920, £120. 6s. 2d.

TIN.—The general position of this metal shows no material alteration. The price-pegging policy has been

DAILY LONDON METAL PRICES: OFFICIAL CLOSING
Copper, Lead, Zinc and Tin per Long

COPPER

	Standard Cash	Standard (3 mos.)	Electrolytic	Wire-Bars	Best Selected
Mar.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.
10	65 17 6 to 66 0 0	66 5 0 to 66 10 0	70 0 0 to 71 0 0	70 0 0 to 71 0 0	68 0 0 to 70 0 0
11	65 15 0 to 66 0 0	66 5 0 to 66 7 6	70 0 0 to 71 0 0	70 0 0 to 71 0 0	67 10 0 to 69 10 0
14	66 2 6 to 66 7 6	66 5 0 to 66 10 0	70 0 0 to 71 0 0	70 0 0 to 71 0 0	67 10 0 to 69 10 0
15	67 0 0 to 67 5 0	66 17 6 to 67 0 0	70 0 0 to 71 0 0	70 0 0 to 71 0 0	67 10 0 to 69 10 0
16	67 0 0 to 67 5 0	66 10 0 to 66 15 0	70 10 0 to 71 10 0	70 10 0 to 71 10 0	67 10 0 to 69 10 0
17	67 0 0 to 67 5 0	66 10 0 to 66 15 0	70 10 0 to 71 10 0	70 10 0 to 71 10 0	67 10 0 to 69 10 0
18	68 0 0 to 68 5 0	66 15 0 to 67 0 0	70 10 0 to 71 10 0	70 10 0 to 71 10 0	67 10 0 to 69 10 0
21	67 15 0 to 68 0 0	66 15 0 to 67 0 0	70 10 0 to 71 10 0	70 10 0 to 71 10 0	67 10 0 to 69 10 0
22	68 0 0 to 68 5 0	66 15 0 to 67 0 0	70 15 0 to 71 15 0	70 15 0 to 71 15 0	67 10 0 to 69 10 0
23	69 0 0 to 69 2 6	68 0 0 to 68 5 0	71 5 0 to 72 5 0	71 5 0 to 72 5 0	67 10 0 to 69 10 0
24	69 7 6 to 69 10 0	68 10 0 to 68 12 6	71 10 0 to 73 0 0	71 10 0 to 73 0 0	69 0 0 to 71 0 0
29	69 12 6 to 69 15 0	69 2 6 to 69 5 0	71 10 0 to 73 0 0	71 10 0 to 73 0 0	69 0 0 to 71 0 0
30	70 12 6 to 70 15 0	70 0 0 to 70 5 0	72 10 0 to 74 0 0	72 10 0 to 74 0 0	69 0 0 to 71 0 0
31	70 0 0 to 70 5 0	69 10 0 to 69 12 6	72 10 0 to 74 0 0	72 10 0 to 74 0 0	69 0 0 to 71 0 0
April					
1	69 0 0 to 69 5 0	68 10 0 to 68 12 6	72 10 0 to 73 10 0	72 10 0 to 73 10 0	70 0 0 to 72 0 0
4	68 0 0 to 68 5 0	67 10 0 to 67 15 0	72 10 0 to 73 10 0	72 10 0 to 73 10 0	70 0 0 to 72 0 0
5	68 7 6 to 68 10 0	68 0 0 to 68 2 6	71 10 0 to 73 10 0	72 10 0 to 73 10 0	70 0 0 to 72 0 0
6	68 15 0 to 68 17 6	68 10 0 to 68 12 6	71 10 0 to 73 10 0	72 10 0 to 73 10 0	70 0 0 to 72 0 0
7	69 0 0 to 69 5 0	68 15 0 to 69 0 0	72 10 0 to 73 10 0	72 10 0 to 73 10 0	70 0 0 to 72 0 0
8	68 17 6 to 69 0 0	68 15 0 to 69 0 0	72 10 0 to 73 10 0	72 10 0 to 73 10 0	70 0 0 to 72 0 0

abandoned in the Straits, but the fact remains that a considerable accumulation of tin exists in the hands of the Federated Malay States Government. In regard to this it is understood that the authorities in the Straits have come to an agreement with those in the Dutch East Indies that their respective stocks shall not be thrown on the market, this understanding to remain in operation to the end of May, when presumably matters will be reconsidered. This announcement did not have any particular effect upon the market, for the reason that it had for some time been understood that the F.M.S. Government had not intended sacrificing their stocks at a loss, and in any case the agreement does not refer to current production. In the meantime, business has been initiated once more in the Straits and also with Batavia, although no great quantities appear to have changed hands in either quarter. So far as demand is concerned this has been very unsatisfactory. Only a very small business has been doing with home consumers, as is understandable in view of the slackness of the tinplate trade America has done a little business now and then, but nothing to speak of, while Continental demand has also been restricted. A factor which should not be lost sight of is the possibility of a 10% ad valorem duty being imposed on imports of tin into the United States. If this tariff were definitely decided upon it might create some demand for metal now in this country to be shipped over there in order to get in before the duty is put on. In the meanwhile, however, world supplies are ample, and consumption poor, and for that reason it is difficult to see any big price advance in sight. At the same time, at the current comparatively low level of values operators are cautious in selling short. During the month of March the prices fluctuated without any very definite tendency.

Average price of cash standard tin: March 1921, £156. 4s. 7d.; February 1921, £166. 9s. 1d.; March 1920, £369. 14s. 5d.; February 1920, £395. 16s. 6d.

LEAD.—Values of this commodity recovered somewhat during the month of March from the comparatively low level touched towards the end of the previous month. It is difficult to give any very definite reason for the improvement, except that the low level referred to appeared to attract dealers, and also to some extent consumers, with the result that prices improved. Speaking generally, however, the quantities going into consumption remain exceedingly restricted, while supplies of metal are steadily coming forward. A certain amount of speculative interest has been seen in the market, possibly based upon the hope that the reduction in the bank rate which is expected will be the means of stimulating trade and giving a greater outlet for the metal. In regard to stocks abroad, there is no definite news as to how much is held in Spain, but a good quantity is believed to be there. The new reparation proposals in regard to Germany might be the means of retarding further supplies from there, but these were not, after all, an important factor in the situation. A feature recently has been further arrivals from Belgium. Australia virtually remains out of the picture so far as lead supplies are concerned. The American market has shown a fluctuating tendency. It is believed in some quarters that the duty on imports into the United States might be raised, in which case some shipments from here might take place with the object of getting the metal into America before the increase takes place. It is possible that some of the firmness seen in the market here was due to such anticipations.

Average price of soft pig lead: March 1921, £19. 2s. 9d.; February 1921, £21; March 1920, £47. 1s. 9d; February 1920, £50. 12s. 9d

SPELTER.—Business in this article with the consuming trades was a little brisker during the month of March, but the takings of consumers still remain very restricted. At one time some anxiety was felt in regard to supplies from Germany. It was feared that the new reparation proposals, whereby 50% of the value of such imports have to be paid to our Government, would be the means of stopping supplies, and as a consequence the market showed considerable firmness. However, fears in regard to the immediate future were dispelled by the announcement that purchases made prior to March 8 and arriving before April 15 would be exempt, and with certain quantities coming forward from Germany, values eased off. So far as future offers from Germany are concerned it is difficult to see exactly how matters will shape themselves. In the meanwhile little has been offering from that quarter, but some business has been done both with Scandinavia and Belgium. Only limited quantities appear to be procurable from the latter coun-

Prices on the London Metal Exchange.

Tons; Silver per Standard Ounce; Gold per Fine Ounce.

Lead: Soft Foreign (£ s. d. £ s. d.)	Lead: English (£ s. d.)	Zinc (Spelter) (£ s. d. £ s. d.)	Standard Tin: Cash (£ s. d. £ s. d.)	Standard Tin: 3 mos. (£ s. d. £ s. d.)	Silver: Cash	Silver: Forward	Gold (s. d)	
								Mar.
19 0 0 to 19 10 0	20 10 0	26 0 0 to 26 5 0	149 10 0 to 150 0 0	153 0 0 to 153 10 0	31¾	30⅞	105 7	10
18 10 0 to 19 2 6	20 0 0	26 5 0 to 26 10 0	155 10 0 to 156 0 0	159 0 0 to 159 10 0	31½	31	105 3	11
19 0 0 to 19 7 6	20 10 0	26 7 6 to 26 12 6	159 10 0 to 160 0 0	163 10 0 to 164 0 0	33½	32½	105 2	14
19 0 0 to 19 7 6	20 10 0	26 0 0 to 26 7 6	157 0 0 to 157 10 0	160 0 0 to 160 10 0	33½	31⅞	105 6	15
18 17 6 to 19 2 6	20 10 0	25 10 0 to 26 2 6	153 0 0 to 153 5 0	156 0 0 to 156 10 0	32½	31⅝	105 1	16
18 15 0 to 19 0 0	20 0 0	24 17 6 to 25 10 0	156 0 0 to 156 5 0	159 5 0 to 159 10 0	32¼	31¾	105 4	17
18 15 0 to 19 0 0	20 0 0	25 0 0 to 25 17 6	154 15 0 to 155 0 0	157 15 0 to 158 0 0	32¾	32⅛	105 0	18
19 0 0 to 19 5 0	20 0 0	25 0 0 to 26 0 0	156 0 0 to 156 10 0	159 10 0 to 160 0 0	33⅝	33	104 10	21
19 0 0 to 19 7 6	20 5 0	25 2 6 to 26 2 6	157 0 0 to 157 5 0	160 10 0 to 160 15 0	34⅛	33¾	105 0	22
19 7 6 to 19 15 0	20 10 0	25 10 0 to 26 10 0	160 5 0 to 160 10 0	164 0 0 to 164 5 0	33⅛	32⅞	105 0	23
20 5 0 to 20 15 0	21 10 0	25 10 0 to 26 12 6	165 10 0 to 165 15 0	168 0 0 to 168 10 0	33⅛	32⅞	104 11	24
20 2 6 to 20 12 6	21 10 0	25 5 0 to 26 10 0	161 10 0 to 161 12 6	165 0 0 to 165 5 0	33¼	33	104 11	29
20 0 0 to 20 10 0	21 10 0	24 5 0 to 26 0 0	159 10 0 to 159 15 0	162 15 0 to 163 0 0	33⅜	33	104 6	30
20 0 0 to 20 7 6	21 5 0	24 5 0 to 25 15 6	158 10 0 to 159 0 0	162 0 0 to 162 10 0	33⅛	32⅝	104 9	31
								April
19 15 0 to 20 2 6	21 5 0	24 5 0 to 25 15 0	157 5 0 to 157 10 0	160 15 0 to 161 0 0	32⅛	32⅛	104 10	1
19 7 6 to 19 15 0	20 15 0	24 0 0 to 25 10 0	154 0 0 to 154 5 0	157 0 0 to 157 10 0	33⅛	32¼	105 0	4
19 10 0 to 19 17 6	21 0 0	24 5 0 to 25 15 0	152 10 0 to 152 15 0	156 5 0 to 156 10 0	33	32¼	105 5	5
20 0 0 to 20 7 6	21 10 0	24 15 0 to 26 0 0	154 10 0 to 155 0 0	157 15 0 to 158 0 0	33¼	32¾	104 11	6
20 5 0 to 20 12 6	21 15 0	25 0 0 to 26 10 0	158 10 0 to 158 15 0	161 10 0 to 162 0 0	33⅛	32⅞	104 7	7
20 10 0 to 20 17 6	22 0 0	25 7 6 to 26 7 6	159 10 0 to 159 15 0	163 0 0 to 163 5 0	33⅜	33	104 11	8

try, as they are by no means pressing sales. So far as America is concerned that country has not been a factor in this market one way or another. The future of the market here is very obscure. This country has been relying largely for some time past on German supplies, and the market here has been practically based on the price at which Germany offered. It would be natural to suppose that the new 50% regulation, already referred to, would be the means, if anything, of restricting offers from Germany, or at least of making their prices higher, but whether such apprehensions are felt or not the market so far has not reflected them materially.

Average price of spelter: March 1921, £25. 10s. 5d.; February 1921, £25. 5s. 5d.; March 1920, £54. 16s. 7d.; February 1920, £62. 3s. 6d.

Zinc Dust.—The market is quiet and prices are easier. High-grade Australian stands at about £55 per ton upwards, American at £57. 10s. to £62. 10s., and English at £60 per ton.

Antimony.—The price of English regulus remains at £37 to £40 for ordinary brands and £38. 5s. to £42 for special brands. Foreign regulus on spot is quoted at £23. 10s. to £25 per ton in warehouse.

Arsenic.—The market is stagnant, Cornish white being nominal around £48 to £50 per ton delivered.

Bismuth.—The chief interest continues to quote 7s. 6d. per lb.

Cadmium.—The market is quiet, with the quotation 6s. to 6s. 3d. per lb.

Aluminium.—The price has kept steady of late at £150 per ton for both home and export.

Nickel.—£200 per ton is quoted for both home and export business.

Cobalt Metal.—Business is quiet, and the present price is 19s. per lb

Cobalt Oxide.—Black oxide is quoted at 16s. and grey at 17s. 6d.

Platinum and Palladium.—Manufactured metal (sheets and wire) is quoted at £19 per oz., but raw platinum in substantial parcels is obtainable around £17 per oz., and palladium at £15.

Quicksilver.—The market is quiet and without any special feature. The price has kept steady at £12. 10s. to £12. 15s. per bottle.

Selenium.—Business is quiet, with 10s. 6d. to 13s. per lb. quoted by sellers.

Tellurium.—There is no change in the quotation, which continues at 90s. to 95s. per lb.

Sulphate of Copper.—The tendency recently has been weaker, the present price being about £34 per ton.

Manganese Ore.—The market is quiet and weak, the latest quotation for Indian grades being 1s. 4d. to 1s. 5d. per unit c.i.f. U.K.

Tungsten Ores.—There is practically no business passing in the market, and sellers are reluctant to sell at less than 13s. 6d. to 14s., although buyers' ideas are below these figures.

Molybdenite.—85% is quoted at 55s. to 65s. per unit c.i.f. U.K.

Chrome Ores.—The quotation for 48% is £5. 10s. to £6 per ton c.i.f. U.K.

Silver.—Spot standard bars opened the month at 32½d., declined to 30⅝d. on March 5, and then recovered till 34⅛d. was reached on the 22nd. The quotation later receded, however, and the price on March 31 was 33⅛d.

Graphite.—The price of Madagascar 80 to 90% is £20 to £25 per ton.

Iron and Steel.—At the beginning of March the Cleveland ironmasters brought their selling price down by about 45s. per ton, making No. 3 Cleveland 150s. for home and 155s. for export. This reduction was followed by other makers, but did not do much to stimulate consumption, and production has had to be drastically curtailed. In the finished iron and steel branches, the amount of new business which has been passing during the last month has been very small, and works have been only able to carry on to a restricted extent. The Continental works too are badly off for orders and have been forced to make severe cuts in their prices in order to secure what business was about. In this country, certain price reductions have been made, but prices are still far too high to permit of a revival of good trade. The coal position looks like dealing a further disastrous blow to the iron and steel trades, the extent of which it is impossible to estimate at the time of writing. In spite of it, however, Cleveland ironmasters, early in April, made a further cut in their prices of 30s. per ton, thus bringing the price of No. 3 to 120s. per ton for the home trade.

STATISTICS.

PRODUCTION OF GOLD IN THE TRANSVAAL

	Rand	Elsewhere	Total	Price of
	Oz	Oz	Oz	Gold per oz.
Year 1919	8,111,271	218,820	8,330,091	s. d.
January, 1920	653,295	17,208	670,503	107 6
February	607,918	17,412	625,330	110 0
March	689,645	17,391	707,036	105 0
April	667,926	19,053	686,979	102 6
May	681,551	17,490	699,041	105 0
June	699,199	16,758	715,957	102 6
July	718,521	17,578	736,099	105 0
August	683,604	18,479	702,083	112 6
September	665,486	16,687	682,173	115 0
October	645,819	16,653	662,472	117 6
November	618,525	15,212	633,737	117 6
December	617,549	14,666	632,215	115 0
Total, 1920	7,949,038	204,587	8,153,625	
January, 1921	637,425	14,168	651,593	105 0
February	543,767	14,370	558,137	103 9

NATIVES EMPLOYED IN THE TRANSVAAL MINES.

	Gold mines	Coal mines	Diamond mines	Total
January 31, 1920	176,390	12,766	4,796	193,952
February 29	185,185	12,708	5,217	203,110
March 31	188,564	12,788	5,232	206 584
April 30	189,446	12,951	5,057	207,454
May 31	184,722	12,897	4,793	202,412
June 30	179,827	13,036	4,596	197,459
July 31	174,187	13,005	4,521	191,713
August 31	169,263	13,535	4,244	187,042
September 30	163,132	13,716	4,323	181,171
October 31	159,426	13 858	4,214	177,498
November 30	158,773	14,245	3,504	176,522
December 31	159,671	14,263	3,340	177,274
January 31, 1921	165,287	14,541	3,319	183,147
February 28	171,518	14,697	1,612	187,827

COST AND PROFIT ON THE RAND

Compiled from official statistics published by the Transvaal Chamber of Mines. The profit available for dividends is about 65% of the working profit. Figures for yield and profit for 1919 based on par value of gold; subsequently gold premium included

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d	s. d	s. d.	£
Year 1919	24,043,638	28 7	22 11	5 6	6,605,509
January, 1920	2,038 092	34 4	24 2	10 2	1,036,859
February	1,869,180	35 1	28 3*	6 10*	644,571*
March	2,188,104	31 8	25 2	6 6	716,610
April	2,065,446	31 5	26 3	5 2	533,940
May	2,117,725	31 9	25 11	5 10	618,147
June	2,146,890	31 10	25 2	6 8	692,510
July	2,194,050	33 6	24 6	9 0	985,058
August	2,057,560	36 11	25 0	11 11	1,226,906
September	1,950,410	38 11	25 6	13 5	1,276,369
October	1,871,140	39 9	26 1	13 8	1,278,385
November	1,799,710	40 2	26 3	13 1	1,255,749
December	1,797,970	39 11	26 8	13 3	1,193 672
January, 1921	1,895,235	35 0	26 3	8 9	829,436

* Results affected by the back-pay disbursed in accordance with new wages agreement.

PRODUCTION OF GOLD IN RHODESIA

	1919	1920	1921
	£	oz.	oz.
January	211,917	43,428	46,956
February	220,885	44,237	40,816
March	225,808	[illegible]	—
April	213 160	47,000	—
May	218,057	46,266	—
June	214,215	[illegible]	—
July	214,919	46,208	—
August	207 339	48,740	—
September	223,719	45,471	—
October	204,184	47,343	—
November	186,462	46,782	—
December	[illegible]	46,190	—
Total	2,499,498	552,498	93,772

TRANSVAAL GOLD OUTPUTS

	February		March	
	Treated	Yield	Treated	Yield
	Tons	Oz.	Tons	Oz.
Aurora West	7,080	[illegible]	10,000	£14,595†
Brakpan	48,500	19,937	52,000	22,339
City Deep	52,500	[illegible]	85,000	36,584
Cons. Langlaagte	14 300	£27,987†	42 000	£62,419†
Cons. Main Reef	33,000	11,515	47,800	16,759
Crown Mines	124,000	42,328	187,000	[illegible]
Durban Roodepoort Deep	24,550	[illegible]	26,500	8,778
East Rand P.M.	112,000	29,099	131,500	31,270
Ferreira Deep	22,500	7,457	[illegible]	10,290
Geduld	40,000	14,058	45,000	15,359
Geldenhuis Deep	39,760	10,804	46,950	12,781
Glynn's Lydenburg	5,560	£5,501	3,277	£4,990†
Goch	12,000	£13,898†	16,600	£20,284†
Government G.M. Areas	111,500	£231,400†	136,000	£283,290†
Kleinfontein	43,800	11,723	48,000	13,297
Knight Central	21,300	5,469	25,500	6,178
Langlaagte Estate	27,100	£45,283†	40,000	£62,290†
Luipaard's Vlei	14,360	£16,905†	*	*
Meyer & Charlton	9,700	£31,540†	14,300	£45,361†
Modderfontein	83,000	39,580	92,000	43,114
Modderfontein B	50,000	25,324	57,000	29,200
Modderfontein Deep	39,400	21,656	42,700	22,809
Modderfontein East	25,000	9,883	26 000	10,430
New Unified	9,300	£10,762†	10,900	£13,219†
Nourse	35,600	11,678	42,000	13,253
Primrose	20,300	£22,328†	21,700	£24,397†
Randfontein Central	100,500	£162,605†	120,000	£187,469†
Robinson	26,700	5,769	39,800	7,814
Robinson Deep	39,200	12,208	60,100	17,279
Roodepoort United	22,000	£22,224†	23,000	£22,209†
Rose Deep	47,500	10,748	53,300	12,871
Simmer & Jack	53,200	12,657	61,100	13,540
Springs	29,500	12,843	42,000	18,776
Sub Nigel	9,500	5,066	9,900	5,557
Transvaal G.M. Estates	14,835	£26,129‡	13,945	£22,415‡
Van Ryn	28,100	£44,519†	31,100	£47,453†
Van Ryn Deep	46,800	£127,877†	50,600	£138,977†
Village Deep	43,300	13,475	48,700	14,643
West Rand Consolidated	30,100	£45,789†	32,300	£48,892†
Witwatersrand (Knights)	28,500	£43,041†	32,000	£47,940†
Witwatersrand Deep	32,060	£49,205†	*	*
Wolhuter	23,600	5,928	32,200	8,291

* Returns not yet received. † £5. 3s. 9d. per oz. ‡ £5. 2s. 9d. per oz

WEST AFRICAN GOLD OUTPUTS.

	January		February	
	Treated	Value	Treated	Value
	Tons	Oz.	Tons	Oz.
Abbontiakoon	6,330	£9,304*	6,057	£9,543*
Abosso	5,000	1,989	4,240	1,696
Akoko	—	—	—	—
Ashanti Goldfields	4,691	5,375	4,603	5,059
Obbuassi	680	£2,252†	662	£2,414†
Prestea Block A	7,898	£14,534*	6,923	£12,914*
Taquah	2 755	1,620	2,500	1,627

* At par. † Including premium.

RHODESIAN GOLD OUTPUTS.

	January		February	
	Treated	Oz	Treated	Oz.
	Tons		Tons	
Cam & Motor		—	8,200	1,495
Falcon	15,301	2,803*	15,103	2,894‖
Gaika	2,813	1,383	3,211	1,356
Globe & Phoenix	5,949	7,206	5,364	6 319
Jumbo	—	—	790	343
London & Rhodesian	—	-	2,213	£2,799
Lonely Reef	5,350	5,219	4,900	4,776
Planet-Arcturus	5,750	2,535	5,470	2,662
Rezende	5,436	2,536	5,100	2,466
Rhodesia, Ltd.	-		—	
Rhodesia G.M. & I.	661	253	509	194
Shamva	50,700	£40,450§	25,500	£17,795‡
Transvaal & Rhodesian	1,550	£5,446†	1,450	£5,116†

* Also 241 tons copper. § Gold at 110s. per oz. † At par. ‡ Gold at £5 per oz. ‖ Also 251 tons copper.

West Australian Gold Statistics.—Par Values.

	Reported for Export oz.	Delivered to Mint oz.	Total oz.	Total value £
January, 1920	836	25,670	26,506	112,590
February	1,928	49,453	51,381	218,251
March	—	54,020	54,020	229,461
April	835	56,256	57,091	242,506
May	227	50,976	51,203	217,495
June	502	56,679	57,181	242,638
July	-	48,341	48,341	205,340
August	167	54,258	54,425	231,185
September	141	54,940	55,081	233,963
October	174	53,801	53,975	229 275
November	128	54,729	54,857	233,017
December	321	53,595	53,916	229,057
January, 1921	523	50,934	51,457	218,574
February	684	26,872	27,556	117,050
March	10	47,875	47,885	203,401

Australian Gold Returns.

	Victoria.		Queensland.		New South Wales	
	1919	1920	1919	1920	1920	1921
	£	Oz.	£	Oz.	£	£
January	36,238	7,105	37,100	4,724	28,000	20,463
February	46,955	8,677	43,330	7,200	15,000	21,575
March	40,267	24,126	48,000	6,973	22,000	
April	63,818	6,368	61,200	8,368	12,000	
May	37,456	13,263	38,200	8,432	13,800	
June	41,465	15,707	44,600	13,725	8,700	
July	37,395	12,782	42,060	9,596	17,410	—
August	51,564	12,809	49,700	9,973	17,168	—
September	76,340	13,973	37,120	11,789	13,872	—
October	39,018	13,432	36,100	9,300	24,752	—
November	40,735	9,245	32,720	10 200	16,907	—
December	63,311	15,305	44,500	12,874	18,137	—
Total	575,260	152,792	514,630	114,181	207,746	42,038

Australasian Gold Outputs.

	January.		February	
	Treated Tons	Value £	Treated Tons	Value £
Associated G.M. (W.A.)	2,677	2,907‖	5,355	7,601‖
Blackwater (N.Z.)	2,129	3,471‖	2,710	4,732‖
Bullfinch (W.A.)	5,350	5,528	4,550	5,377
Golden Horseshoe (W.A.)	3,528	1,772‡	9,084	4,669‡
Great Boulder Pro. (W.A.)	3,544	10,623‖	8,080	25,048‖
Ivanhoe (W.A.)	4,987	2,193‡	13,705	5,029‡
Kalgurli (W.A.)		—	4,703	7,261‖
Lake View & Star (W.A.)	—	—	7,344	9,969†
Menzies Con. (W.A.)	1,360	2,289	1,360	2,604
Mount Boppy (N.S.W.)	5,672	1,760‡	5,751	1,393‡
Oroya Links (W.A.)	-	—	2,063	11,660†
Progress (N.Z.)			—	—
Sons of Gwalia (W.A.)	—	—	—	-
South Kalgurli (W.A.)	-	—	8,830	17,830‖
Waihi (N.Z.)	7,087	1,787 23,654	12,830	3,472 20,971
Waihi Grand Junc'n (N.Z.)		—	**10,710	3,119 13,690
Yuanmi (W.A.)	1,320	4,123*	1,063	3,423*

† Including royalties; ‡ Oz. gold, § Oz silver. ‖ At par; * Including premium. ** 7 weeks.

Miscellaneous Gold and Silver Outputs

	January		February	
	Treated Tons	Value £	Treated Tons	Value £
Brit. Plat & Gold (C'lbia)		221§	-	229§
El Oro (Mexico)	29,500	200,000†	28,250	201,000†
Esperanza (Mexico)	—	1,249‡†	—	-
Frontino & Bolivia (C'lbia)	2,020	5,558	2,680	8,268
Mexico El Oro (Mexico)	12,050	163,240†	9,425	158,980†
Mining Corp. of Canada		39,729*	—	
Oriental Cons. (Korea)		75,500†		92,500†
Ouro Preto (Brazil)	6,300	2,082‖	6,300	2,076‖
Plymouth Cons. (Calif'rnia)	9,000	11,435	8,100	10,374
St. John del Rey (Brazil)		35,000		38,300
Santa Gertrudis (Mexico)	37,588	10,104‡	32,407	1,233‡
Tolima (Colombia)	75**	—	60**	
Tomboy (Colorado)	15,000	71,000†	14,000	56,000†

† U.S. Dollars. ‡ Profit, gold and silver ‖ Oz. gold. * Oz. silver. § Oz. platinum and gold. ** Production of silver ore.

Pato (Colombia): 17 days to March 4, $24,184 gold from 57,110 cu. yd.; 12 days to 16 March, $20,237 from 41,976 cu yd.

Nechi (Colombia): 28 days to March 1, $57,529 gold from 202,097 cu. yd., 13 days to March 14, $28,416 from 101,045 cu yd

Production of Gold in India.

	1917	1918	1919	1920	1921
	oz.	oz.	oz.	oz.	oz.
January	44,718	41,420	38,184	39,073	34,028
February	42,566	40,787	36,834	38,872	32,529
March	44,617	41,719	38,317	38,760	32,576
April	43,726	41,504	38,248	37,307	—
May	42,901	40,889	38,608	38,191	—
June	42,924	41,264	38,359	37,864	—
July	42 273	40,229	38,549	37,129	—
August	42 591	40,496	37,850	37,375	
September	43,207	40,088	36,813	35,497	—
October	43,041	39,472	37,138	35,023	-
November	42,915	36,984	39,628	34,522	—
December	44,883	40,149	42,643	34,9 9	—
Total	520,362	485,236	461,171	444,532	99,133

Indian Gold Outputs

	February.		March.	
	Tons Treated	Fine Ounces	Tons Treated	Fine Ounces
Balaghat	3,000	2,220	3,250	2,324
Champion Reef	10,831	4,561	11,710	4,407
Mysore	15,950	11,563	15,573	11,285
North Anantapur	700	917	700	908
Nundydroog	8,324	4,901	8,952	5,204
Ooregum	12 500	8,367	12,900	8,448

Base Metal Outputs.

		Jan.	Feb.
Arizona Copper	Short tons copper	1,150	1,000
British Broken Hill	Tons lead conc.	1,320	-
	Tons zinc conc.	1,190	-
	Tons carbonate ore.	40	—
Broken Hill Prop	Tons lead conc.	845	—
	Tons zinc conc	2,460	—
Broken Hill South	Tons lead conc	1,693	2,770
Burma Corp.	Tons refined lead	2,548	2,601
	Oz. refined silver	234,487	231,664
Fremantle Trading	Long tons lead	473	370
Hampden Cloncurry	Tons copper	—	—
	Oz. gold	—	—
Kafue Copper	Short tons copper	—	—
Mount Lyell	Tons copper	672*	406
	Oz silver	24,277*	12,816
	Oz. gold	72*	409
Mount Morgan	Tons copper	340	975†
	Oz. gold	4,485	13,025†
North Broken Hill	Tons lead	—	—
	Oz silver	—	—
Pilbara Copper	Tons ore	170	203
Poderosa	Tons copper ore	150	420
Rhodesian Broken Hill	Tons lead	1,442	1,215
S'th American Copper	Tons cop. ore ship'd.	—	—
Sulphide Corporation	Tons lead conc.	1,585	1,811
	Tons zinc conc.	2,580	2,990
Tanganyika	Long tons copper	1,290	1,467
Zinc Corp.	Tons zinc conc.	4,015	7,650
	Tons lead conc.	287	552

* Dec. 16 to Feb. 9. † 8 weeks to March 20.

Imports of Ores, Metals, etc., into United Kingdom

		Feb., 1921	Mar., 1921.
Iron Ore	Tons	283,839	257,324
Manganese Ore	Tons	35,193	20,987
Copper and Iron Pyrites	Tons	40,719	38,166
Copper Ore, Matte, and Precipitate	Tons	3,555	932
Copper Metal	Tons	7,186	12,483
Tin Concentrate	Tons	2,546	2,255
Tin Metal	Tons	1,581	576
Lead, Pig and Sheet	Tons	14,684	12,560
Zinc (Spelter)	Tons	4,319	5,803
Quicksilver	Lb.	16,982	378 750
Zinc Oxide	Tons	230	342
White Lead	Cwt.	5,939	4,889
Barytes, ground	Cwt.	22,646	18 588
Phosphate	Tons	37,465	25 726
Sulphur	Tons	—	6,435
Borax	Cwt.	960	1,059
Other Boron Compounds	Tons	1,478	3,448
Nitrate of Soda	Cwt.	133,664	58,079
Nitrate of Potash	Cwt.	7,525	12,716
Petroleum:			
Crude	Gallons	920,111	—
Lamp Oil	Gallons	14,621,851	11,603,953
Motor Spirit	Gallons	13,775,416	23,056,818
Lubricating Oil	Gallons	3,392,702	3,841,085
Gas Oil	Gallons	3,193,753	4,282,603
Fuel Oil	Gallons	33,515,259	41,148,617
Total Petroleum	Gallons	69,420,821	83,938,899

Outputs of Tin Mining Companies.

In Tons of Concentrate

Nigeria	Dec. Tons	Jan. Tons	Feb. Tons
Associated Nigerian	20	7	
Bisichi	10	5	[illegible]
Bongwelli	[illegible]	5	
Champion (Nigeria)	[illegible]		
Dua	[illegible]	[illegible]	1¼
Ex-Lands	[illegible]	30	20
Filani	5½	[illegible]	3½
Gold Coast Consolidated	3		
Gurum River	12	[illegible]	12
Jantar	[illegible]		
Jos	[illegible]		15
Kaduna	[illegible]	14	14¾
Kaduna Prospectors	[illegible]	[illegible]	[illegible]
Kano		[illegible]	4
Lower Bisichi	[illegible]	[illegible]	5¾
Lucky Chance	1		[illegible]
Minna	[illegible]	1	1½
Mongu	50	51	60
Naraguta	42	35	
Naraguta Extended	[illegible]	10	10
Nigerian Consolidated	23	17	[illegible]
N.N. Bauchi	50	[illegible]	[illegible]
Ofin River	9¼		
Rayfield	37	[illegible]	[illegible]
Ropp	126	86	82
Rukuba	4½	4	
South Bukeru	15	18	¾
Sybu	4½	1	
Tin Fields	4	4	4
Yarde Kerri	5	5½	—
Federated Malay States:			
Chenderiang	103*	—	—
Gopeng	66	[illegible]	[illegible]
Idris Hydraulic	17¾		21
Ipoh	19½	19¼	15[illegible]
Kamunting	120*	—	—
Kinta	[illegible]	51¼	28¾
Lahat	60¼	68¼	56½
Malayan Tin	[illegible]	80½	80½
Pahang	166	166	136
Rambutan	15	16½	15
Sungei Besi	30	33	35
Tekka	30	25½	29
Tekka-Taiping	27	21	15
Tronoh	29	36	19
Cornwall:			
East Pool	89¾†	95	
Geevor	—		
South Crofty	62[illegible]	55	—
Other Countries:			
Aramayo Francke (Bolivia)	154	157	130
Berenguela (Bolivia)	18	24	26
Briseis (Tasmania)	13	11	[illegible]
Deebook Ronpibon (Siam)	30½	20	16
Leeuwpoort (Transvaal)	247*		
Macready (Swaziland)	19*	—	—
Renong (Siam)	[illegible]	90	31½
Rooiberg Minerals (Transvaal)		45	45
Siamese Tin (Siam)	71¾	83	50
Tongkah Harbour (Siam)	73	67	33
Zaaiplaats (Transvaal)	27	21	13

* Three months. † Tin and wolfram.

Nigerian Tin Production.

In long tons of concentrate of unspecified content.

Note. These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual outputs.

	1916	1917	1918	1919	1920	1921
	Tons	Tons	Tons	Tons	Tons	Tons
January	531	667	678	613	547	438
February	528	646	668	623	477	370
March	547	655	707	606	505	—
April	486	555	584	546	467	
May	536	509	525	483	383	—
June	510	473	492	484	435	
July	506	479	545	481	484	—
August	498	551	571	616	447	
September	535	538	520	561	528	
October	584	578	491	625	628	
November	679	621	472	536	544	
December	654	655	518	511	577	
Total	6,594	6,927	6,771	6,685	6,022	808

Production of Tin in Federated Malay States.

Estimated at 70% of Concentrate shipped to Smelters.
Long Tons

	1917	1918	1919	1920	1921
	Tons	Tons	Tons	Tons	Tons
January	3,558	3,030	3,765	4,265	3,298
February	2,755	3,197	2,734	3,014	3,111
March	3,286	2,609	2,819	2,770	
April	3,251	3,308	2,858	2,606	
May	3,413	3,332	3,407	2,741	
June	3,489	3,070	2,877	2,940	
July	3,253	3,373	3,756	2,824	
August	3,413	3,259	2,956	2,786	
September	3,154	3,157	3,161	2,734	
October	3,436	2,870	3,221	2,837	
November	3,300	3,132	2,972	2,573	
December	3,525	3,022	2,409	2,838	—
	39,833	37,370	36,935	34,9[illegible]	6,409

Stocks of Tin.

Reported by A. Strauss & Co. Long Tons.

	Jan. 31	Feb. 28	Mar. 31
Straits and Australian Spot	2,701	2,12[illegible]	1,738
Ditto, Landing and in Transit	10	10	80
Other Standard, Spot and Landing	4,960	5,365	5,456
Straits, Afloat	345	40	385
Australian, Afloat	264	295	200
Banca, in Holland	3,341	3,187	2,974
Ditto, Afloat	356	209	
Billiton, Spot	755	755	579
Billiton, Afloat	141		—
Straits, Spot in Holland and Hamburg			—
Ditto, Afloat to Continent	60		95
Total Afloat for United States	2,595	1,385	781
Stock in America	2,546	3,546	3,476
Total	18,104	16,900	15,764

Shipments, Imports, Supply, and Consumption of Tin.

Reported by A. Strauss & Co. Long tons.

	Jan.	Feb.	Mar.
Shipments from:			
Straits to U.K.	35	20	395
Straits to America	960	220	395
Straits to Continent	60		125
Straits to Other Places	106	33	289
Australia to U.K.	350	100	50
U.K. to America	985	715	100
Imports of Bolivian Tin into Europe	341	800	366
Supply:			
Straits	1,055	240	915
Australian	350	100	50
Billiton	—		
Banca	498		79
Standard	1,290	1,561	1,290
Total	3,193	1,961	2,334
Consumption:			
U.K. Deliveries	1,254	1,321	1,359
Dutch	269	164	389
American	1,555	1,585	1,683
Straits, Banca & Billiton, Continental Ports, etc.	490	35	39
Total	3,568	3,568	3,470

Outputs Reported by Oil-Producing Companies.

		Jan.	Feb.	March
Anglo-Egyptian	Tons	18,130	16,991	13,627
Anglo-United	Barrels	6,951	9,219	8,900
Apex Trinidad	Barrels	—	—	43,525
British Burmah	Barrels	61,540	56,023	
Caltex	Barrels	111,880	78,962	—
Dacia Romana	Tons	258	—	—
Kern River	Barrels	110,635	95,010	—
Lobitos	Tons	8,444	7,659	—
Roumanian Consol.	Tons	1,520	1,282	—
Santa Maria	Tons	1,286	1,000	—
Steaua Romana	Tons	18,610	14,991	—
Trinidad Leaseholds	Tons	12,750	11,400	13,400
United of Trinidad	Tons	4,258	3,767	—

Quotations of Oil Companies' Shares.

Denomination of Shares £1 unless otherwise noted.

	March 8, 1921 £ s. d.	April 7, 1921 £ s. d.
Anglo-American	4 10 0	4 7 6
Anglo-Egyptian B.	1 17 6	1 17 6
Anglo-Persian Pref.	1 1 0	1 2 0
Anglo United, Wyoming	12 6	10 0
Apex Trinidad	2 7 6	2 10 0
British Burmah (8s.)	17 6	17 6
Burmah Oil	6 17 6	6 17 6
Caltex ($1)	11 0	7 6
Dacia Romano	1 0 0	17 6
Kern River, Cal (10s.)	1 1 0	1 2 0
Lobitos, Ecuador	4 1 3	3 17 6
Mexican Eagle, Ord ($10)	5 10 0	5 7 6
„ „ Pref. ($10)	5 5 0	5 5 0
North Caucasian (10s.)	12 6	12 6
Phœnix, Roumania	12 0	12 0
Roumanian Consolidated	14 0	12 6
Royal Dutch (100 gulden)	48 0 0	44 0 0
Scottish American	16 6	15 0
Shell Transport, Ord.	5 6 3	5 0 0
„ „ Pref. (£10)	8 0 0	8 0 0
Steaua Romana	15 0	14 3
Trinidad Central	3 10 0	3 5 0
Trinidad Leaseholds	2 7 6	2 5 0
United British of Trinidad	17 6	17 6
Ural Caspian	12 6	13 9
Uroz Oilfields (10s.)	8 9	8 9

Dividends Declared by Mining Companies.

Date	Company	Par Value of Shares	Amount of Dividend
March 26	Balaghat	10s.	1s. 1½d. less tax
April 8	Borax Consolidated	Prf. Ord. £5.	6%
March 17	British Aluminium	Ord. £1	6% less tax
March 16	City & Suburban	£1.	1 City Deep share for every 10 shares held
March 30	Ferreira Deep	£1.	7½%
March 14	Glencairn	£1.	2s.*
March 30	Globe and Phœnix	5s.	2s. tax paid
April 5	Globe and Phœnix	5s.	1s. tax paid
March 24	Gopeng Consolidated	£1.	9d. less tax
March 30	Ivanhoe	£5.	2s. less tax
March 10	Jupiter Gold	£1.	2s. 9d.
March 22	Kern River Oilfields	10s.	7½% less tax
March 10	Knights Deep	£1.	12s.*
March 19	Kramat Pulai	£1.	1s. less tax
March 17	Marbella Iron Ore	£3.	6s. less tax
March 24	Mason & Barry	£1	25% less tax
March 30	Nechi Mines	Pref 10s.	1s. 3d. less tax
March 24	Nundydroog	10s.	1s. less tax
April 8	Ooregum Gold	Ord. 10s.	1s. 6d. less tax
April 6	Pahang Corporation	£1 Pref	3½% less tax
March 24	Shamva Mines	£1.	7½% less tax
March 31	Tharsis Sulphur & Copper	£2.	15% less tax

* First distribution on liquidation.

PRICES OF CHEMICALS. April 9.

These quotations are not absolute; they vary according to quantities required and contracts running.

		£	s	d
Acetic Acid, 40%	per cwt.	1	4	0
„ 80%	„	2	8	0
„ Glacial	„	2	16	0
Alum	per ton	18	0	0
Alumina, Sulphate of	„	16	0	0
Ammonia, Anhydrous	per lb.		2	6
„ 0·880 solution	per ton	46	0	0
„ Carbonate	per lb.			4
„ Chloride of, grey	per ton	50	0	0
„ „ „ pure	per cwt	4	0	0
„ Nitrate of	per ton	50	0	0
„ Phosphate of	„	95	0	0
„ Sulphate of	„	24	0	0
Antimony, Tartar Emetic	per lb.		2	7
„ Sulphide, Golden	„		1	6
Arsenic, White	per ton	50	0	0
Barium Carbonate	„	11	0	0
„ Chlorate	per lb.		1	0
„ Chloride	per ton	20	0	0
„ Sulphate	„	10	0	0
Benzol, 90%	per gal.		3	0
Bisulphate of Carbon	per ton	55	0	0
Bleaching Powder, 35% Cl.	„	19	0	0
„ Liquor, 7%	„	7	0	0
Borax	„	38	0	0
Boric Acid, crystals	„	74	0	0
Calcium Chloride	„	10	0	0
Carbolic Acid, crude 60%	per gal.		1	8
„ crystallized, 40°	per lb.			7
China Clay (at Runcorn)	per ton	£3 10 0 to £4 10 0		
Citric Acid	per lb.		2	3
Copper, Sulphate of	per ton	33	0	0
Cyanide of Sodium, 100%	per lb.		1	0
Hydrofluoric Acid	„			7½
Iodine	per oz.		1	0
Iron, Nitrate of	per ton	8	0	0
„ Sulphate of	„	4	0	0
Lead, Acetate of, white	„	50	0	0
„ Nitrate of	„	51	0	0
„ Oxide of, Litharge	„	38	0	0
„ White	„	40	0	0
Lime, Acetate, brown	„	10	0	0
„ „ grey 80%	„	14	0	0
Magnesite, Calcined	„	21	0	0
Magnesium, Chloride	„	12	0	0
„ Sulphate	„	10	0	0
Methylated Spirit 64° Industrial	per gal.		7	0
Nitric Acid, 80 Tw.	per ton	32	0	0
Oxalic Acid	per lb.		11	0
Phosphoric Acid	per ton	50	0	0
Potassium Bichromate	per lb.			11
„ Carbonate 85%	per ton	45	0	0
„ Chlorate	per lb.		0	6
„ Chloride 80%	per ton	24	0	0
„ Hydrate (Caustic) 90%	„	48	0	0
„ Nitrate	„	55	0	0
„ Permanganate	per lb.		2	0
„ Prussiate, Yellow	„		1	4
„ „ Red	„		2	3
„ Sulphate, 90%	per ton	25	0	0
Sodium Metal	per lb.		1	3
„ Acetate	per ton	30	0	0
„ Arsenate 45%	„	45	0	0
„ Bicarbonate	„	9	0	0
„ Bichromate	per lb.			8
„ Carbonate (Soda Ash)	per ton	15	0	0
„ „ (Crystals)	„	7	0	0
„ Chlorate	per lb.			4½
„ Hydrate, 76%	per ton	27	0	0
„ Hyposulphite	„	20	0	0
„ Nitrate, 95%	„	22	0	0
„ Phosphate	„	26	0	0
„ Prussiate	per lb.			8
„ Silicate	per ton	11	0	0
„ Sulphate (Salt-cake)	„	9	0	0
„ „ (Glauber's Salts)	„	7	0	0
„ Sulphide	„	30	0	0
„ Sulphite	„	13	0	0
Sulphur, Roll	„	13	0	0
„ Flowers	„	13	0	0
Sulphuric Acid, Fuming, 65°	„	24	0	0
„ „ free from Arsenic, 144°	„	6	5	0
Superphosphate of Lime, 30%	„	8	10	0
Tartaric Acid	per lb.		1	9
Turpentine	per cwt.	2	15	0
Tin Crystals	per lb.		1	7
Titanous Chloride	„		1	0
Zinc Chloride	per ton	25	0	0
Zinc Sulphate	„	19	0	0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS:	April 7, 1920 £ s. d.	April 7, 1921 £ s. d.
RAND:		
Brakpan	3 10 0	2 8 9
Central Mining (£8)	9 15 0	5 15 0
City & Suburban (£4)	6 9	1 18 9
City Deep	2 15 0	6 3
Consolidated Gold Fields	1 15 0	16 3
Consolidated Langlaagte	1 5 0	11 3
Consolidated Main Reef	13 6	9 6
Consolidated Mines Selection (10s.)	1 11 9	13 3
Crown Mines (10s.)	3 6 3	1 15 0
Daggafontein	18 0	2 6
Durban Roodepoort Deep	9 0	2 0
East Rand Proprietary	11 3	4 0
Ferreira Deep	13 0	9 6
Geduld	2 10 0	2 5 0
Geldenhuis Deep	12 6	5 6
Gov't Gold Mining Areas	4 12 6	3 15 0
Heriot	10 0	—
Johannesburg Consolidated	1 12 0	1 2 0
Jupiter	6 0	3 6
Kleinfontein	13 0	5 6
Knight Central	4 9	4 0
Knights Deep	10 0	14 0
Langlaagte Estate	16 6	9 6
Meyer & Charlton	4 15 0	4 0 0
Modderfontein (10s.)	3 18 9	3 2 6
Modderfontein B (5s.)	7 0 0	1 3 9
Modderfontein Deep (5s.)	2 10 0	2 1 3
Modderfontein East	1 6 3	10 6
New State Areas	1 7 6	1 0 0
Nourse	13 9	6 0
Rand Mines (5s.)	3 12 0	2 2 6
Rand Selection Corporation	4 10 0	3 10 0
Randfontein Central	19 0	8 6
Robinson (£5)	12 0	8 6
Robinson Deep A (1s.)	1 2 6	11 3
Rose Deep	1 0 0	11 3
Simmer & Jack	5 3	2 6
Simmer Deep	2 3	—
Springs	2 12 6	1 11 3
Sub-Nigel	17 6	11 3
Union Corporation (12s. 6d.)	1 1 9	15 6
Van Ryn	1 1 3	10 0
Van Ryn Deep	4 13 9	3 12 6
Village Deep	14 9	7 3
Village Main Reef	7 0	—
West Springs	1 0 0	12 6
Witwatersrand (Knight's)	18 9	12 6
Witwatersrand Deep	10 6	7 0
Wolhuter	6 0	4 0
OTHER TRANSVAAL GOLD MINES		
Glynn's Lydenburg	13 9	6 6
Transvaal Gold Mining Estates	13 9	8 0
DIAMONDS IN SOUTH AFRICA:		
De Beers Deferred (£2 10s.)	26 15 0	10 5 0
Jagersfontein	5 17 6	2 5 0
Premier Deferred (2s. 6d.)	11 10 0	4 5 0
RHODESIA		
Cam & Motor	11 9	7 0
Chartered British South Africa	17 3	12 0
Falcon	11 0	7 0
Gaika	14 0	8 0
Globe & Phoenix (5s.)	24 6	19 0
Lonely Reef	2 16 3	1 17 6
Rezende	3 7 6	2 5 0
Shamva	2 0 0	1 8 9
Willoughby's (10s.)	5 6	4 6
WEST AFRICA:		
Abbontiakoon (10s.)	4 0	2 0
Abosso	13 9	8 3
Ashanti (4s.)	1 0 3	13 6
Prestea Block A	4 3	1 9
Taquah	16 3	8 3
WEST AUSTRALIA		
Associated Gold Mines	4 6	2 3
Associated Northern Blocks	4 6	2 3
Bullfinch	6 0	1 0
Golden Horse-Shoe (£5)	1 0 0	12 6
Great Boulder Proprietary (2s.)	9 0	5 6
Great Fingall (10s.)	[illegible] 6	1 6
Hampton Properties	1 11 [illegible]	5 0
Ivanhoe (£5)	2 0 0	17 6
Kalgurli	15 0	7 6
Lake View Investment (10s.)	17 0	9 3
Sons of Gwalia	7 3	4 9
South Kalgurli (10s.)	6 6	6 9

GOLD, SILVER, cont.	April 7, 1920 £ s. d.	April 7, 1921 £ s. d.
OTHERS IN AUSTRALASIA		
Blackwater, New Zealand	2 6	2 6
Consolidated G.F. of New Zealand	2 6	2 6
Mount Boppy, N.S.W. (10s.)	4 0	3 6
Progress, New Zealand	1 9	1 3
Talisman, New Zealand	8 9	
Waihi, New Zealand	2 2 6	1 6 3
Waihi Grand Junction, New Z'lnd	11 3	12 6
AMERICA		
Buena Tierra, Mexico	12 6	6 3
Camp Bird, Colorado	17 6	4 3
El Oro, Mexico	14 6	9 6
Esperanza, Mexico	14 0	15 0
Frontino & Bolivia, Colombia	13 9	8 9
Le Roi No. 2 (£5), British Columbia	10 0	2 6
Mexico Mines of El Oro, Mexico	7 12 6	4 5 0
Nechi (Pref. 10s.), Colombia	10 0	7 6
Oroville Dredging, Colombia	1 7 6	1 2 6
Plymouth Consolidated, California	1 1 3	17 6
St. John del Rey, Brazil	16 0	14 6
Santa Gertrudis, Mexico	1 12 3	6 0
Tomboy, Colorado	13 9	5 0
RUSSIA:		
Lena Goldfields	1 2 6	10 0
Orsk Priority	12 6	5 0
INDIA:		
Balaghat (10s.)	10 0	7 3
Champion Reef (2s. 6d.)	3 6	1 9
Mysore (10s.)	17 0	12 6
North Anantapur	4 0	3 9
Nundydroog (10s.)	13 6	5 6
Ooregum (10s.)	17 0	12 6
COPPER:		
Arizona Copper (5s.), Arizona	2 12 6	1 5 0
Cape Copper (£2), Cape and India	1 17 6	15 0
Esperanza, Spain	5 9	5 0
Hampden Cloncurry, Queensland	15 0	5 0
Mason & Barry, Portugal	2 10 0	1 10 0
Messina (5s.), Transvaal	6 6	4 0
Mount Elliott (£5), Queensland	2 15 0	10 0
Mount Lyell, Tasmania	1 4 6	12 6
Mount Morgan, Queensland	1 5 0	11 3
Mount Oxide, Queensland	7 0	—
Namaqua (£2), Cape Province	1 10 0	17 6
Rio Tinto (£5), Spain	37 0 0	25 5 0
Russo-Asiatic Consd., Russia	10 0	7 3
Sissert, Russia	15 0	5 0
Spassky, Russia	1 2 6	12 6
Tanganyika, Congo and Rhodesia	2 6 3	1 2 6
LEAD-ZINC:		
BROKEN HILL		
Amalgamated Zinc	1 5 0	17 6
British Broken Hill	2 3 9	16 3
Broken Hill Proprietary	3 0 0	1 15 0
Broken Hill Block 10 (£10)	1 6 3	10 0
Broken Hill North	2 16 3	1 2 6
Broken Hill South	2 15 0	1 5 0
Sulphide Corporation (15s.)	19 0	10 0
Zinc Corporation (10s.)	19 6	10 0
ASIA		
Burma Corporation (10 rupees)	11 17 6	7 6*
Russian Mining	13 9	6 6
RHODESIA		
Rhodesia Broken Hill (5s.)	15 3	6 3
TIN:		
Aramayo Francke, Bolivia	4 16 3	1 12 6
Bisichi, Nigeria	15 0	6 3
Briseis, Tasmania	5 3	2 6
Dolcoath, Cornwall	6 9	3
East Pool (5s.) Cornwall	15 0	3 6
Ex-Lands Nigeria (2s.), Nigeria	4 0	1 6
Geevor (10s.) Cornwall	1 0 6	2 6
Gopeng, Malay	2 6 3	1 8 9
Ipoh Dredging, Malay	1 0 3	11 3
Kamunting, Malay	2 10 0	1 7 6
Kinta, Malay	2 17 6	1 10 0
Malayan Tin Dredging, Malay	2 8 9	1 3 9
Mongu (10s.), Nigeria	1 5 6	11 3
Naraguta, Nigeria	16 3	15 0
N. N. Bauchi, Nigeria (10s.)	7 9	1 9
Pahang Consolidated (5s.), Malay	13 0	6 6
Rayfield, Nigeria	13 3	3 0
Renong Dredging, Siam	2 11 3	1 3 9
Ropp (4s.), Nigeria	13 6	6 0
Siamese Tin, Siam	4 13 9	2 2 6
South Crofty (5s.), Cornwall	15 6	4 9
Tehidy Minerals, Cornwall	1 11 3	8 9
Tekka, Malay	5 7 6	15 0
Tekka-Taiping Malay	1 11 3	17 6
Tronoh, Malay	2 11 3	1 2 [illegible]

* 10-rupee shares of Indian Co.

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

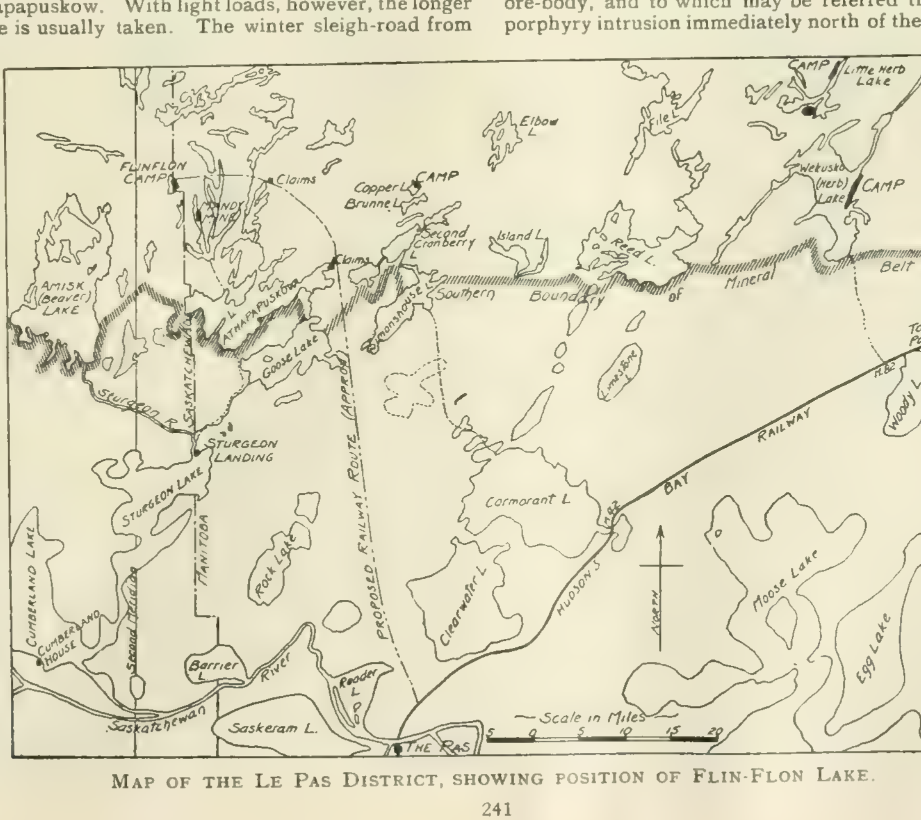
In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also notices of new books and pamphlets, lists of patents on mining and metallurgical subjects, and abstracts of the yearly reports of mining companies.

THE FLIN-FLON ORE-BODY.

The February *Bulletin* of the Canadian Institute of Mining and Metallurgy contains a paper by R. C. Wallace, Commissioner of Northern Manitoba, on the Flin-Flon copper ore-body, which is now being developed. This mine is situated north of Le Pas, Manitoba. A number of references have been made in these columns to this enterprise, the most recent being by Mr. Wallace in the December issue and by E. L. Bruce in October last.

Flin-Flon Lake is distant by air line 68 miles north-north-west from The Pas, through which town the Canadian National Railway passes en route for Hudson's Bay. The Pas is the distributing centre on the Saskatchewan river for the mineral field and for settlements on the Hudson's Bay railway. The summer route from The Pas is by way of the Saskatchewan river to Sturgeon Landing, which is the head of the navigation for steamboat traffic, and thence by canoe to Flin-Flon Lake. The total distance is 130 miles by steamboat and 60 miles by canoe, a total of 190 miles from railway communication. The canoe route can be shortened by using the summer road built by the Provincial Government from Sturgeon Landing to Lake Athapapuskow. With light loads, however, the longer route is usually taken. The winter sleigh-road from The Pas is approximately 90 miles long. The property is near the well-established and historical canoe route from Cumberland House northwards through Lake Athapapuskow and the Pine Root River to the Churchill River at Pukatawagan. The camp lies nine miles west of this route in a territory which was hitherto not frequently travelled between the Pine Root River valley and the Beaver Lake country.

The ore-body lies in amygdaloidal greenstones which are to be referred to the earliest volcanic flows in this district. They have been named by E. L. Bruce, of the Geological Survey, the Amisk volcanics, owing to their prevalence in the vicinity of Amisk (Beaver) lake. Associated with the greenstones, and probably somewhat later in age, although earlier than the granite intrusions, are quartz-porphyries which are parallel in strike to the greenstones and which do not here display clear-cut intrusive relationships into the greenstones. There are also lamprophyric dykes which are apparently earlier than the intrusions of granite, probably earlier than the quartz porphyry flows, though later than the amygdaloidal greenstones. The later granite, which is found one mile south-west of the Flin-Flon ore-body, and to which may be referred the granite-porphyry intrusion immediately north of the ore-body,



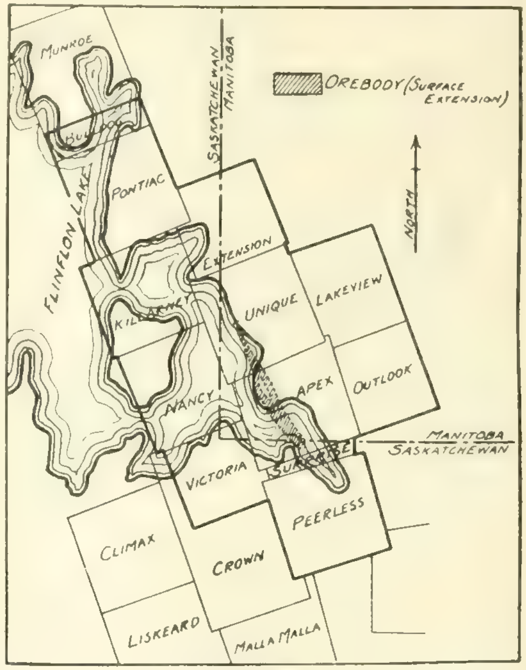
MAP OF THE LE PAS DISTRICT, SHOWING POSITION OF FLIN-FLON LAKE.

has been named by Bruce the Kaminis granite. This granite is intrusive, not only into the volcanics referred to, but also into sediments that overlie the volcanics, but which are not exposed in the immediate vicinity of the Flin Flon property. The Flin Flon and other sulphide deposits of this district, as well as the gold deposits in the quartz veins, are to be referred to this granite as ore deposits representing deposition at lower and higher temperatures respectively.

During the process of shearing, which probably occurred in the earlier stages of the eruption of the Kaminis granite, the quartz porphyry offered greater resistance to the shearing forces than did the amygdaloidal greenstone. In the greenstone itself there are apparently units of greater resistance than others. In all probability the zones that suffered intensive shearing represent a volcanic tuff interbanded with the more massive lava flows. In the process of replacement by sulphides the more sheared zones have suffered much greater change than have the more massive members.

The ore-body, which skirts the south-east shore of the lake, strikes with the country rock and dips approximately 70° east. From the records of diamond-drill holes at the south end of the deposit, it would also appear that the ore-body pitches at a low angle to the south. Horses of unmineralized greenstone separate the ore-body into more or less independent lenses. At the south end of the ore-body a massive greenstone has been less affected by weathering than the sulphides, and stands out as a prominent topographical feature on the property. It would seem, from the, as yet, incomplete drilling at the south end of the deposit, that this horse forms part of a crescent-shaped mass of greenstone open toward the south. The deposit has a known length of 2,593 ft., and has been proved to a depth of 900 ft. over a length of 1,000 ft. Its greatest width transverse to the dip is 400 ft. This figure includes some narrow horses of greenstone. Its greatest transverse width at the 900 ft. level is 35 ft. From the results of diamond-drilling and underground development work, the total tonnage has been calculated to be sixteen million, exclusive of the horses of greenstone in the ore-body. This estimate makes no allowance for possible ore under the 900 ft. level or possible ore at depth in the line of pitch at the south end of the ore-body. On the whole, the ore-body is most compact at the north end and shows a tendency to intermingle with inclusions of considerable widths of country rock towards the south end at depth.

The minerals of the ore-body are, in order of importance, pyrite, zinc blende, and chalcopyrite. Gold and silver are apparently associated mainly with pyrite, the silver in all probability in the form of a mixed silver sulphide. Galena has been found in vugs in the otherwise unmineralized rock, but does not occur in quantity in the ore-body. Native copper is found in leaf form as a secondary product in the upper sulphide zone. For practical purposes the ore is divided into two types: first, solid sulphides; second, disseminated ore. The solid sulphides occur in the centre and toward the hanging wall of the ore-body, and are in places in direct contact with the hanging wall. As a rule, however, a selvage of disseminated ore separates the solid sulphides from the hanging wall; while on the foot-wall there is found invariably a considerable width of disseminated ore. The hanging wall disseminated ore is found to carry smaller percentages of copper and a greater proportion of gold and silver than the disseminated ore on the foot-wall; in other words the deposition of pyrite is more extensive on the hanging wall side of the ore-body, and the deposition of chalcopyrite is more extensive on the foot-wall side. As far as has yet been ascertained the same holds true (though to a lesser degree) with the solid sulphide, which gives the higher values in copper on the foot-wall side. The solid sulphides are broken by masses of unmineralized rock and the contact between solid ore and rock is, generally speaking, sharp; as a rule, also, contact between disseminated ore and sulphide is distinct, though in the underground workings a distinct gradation may be noted in places. The richest copper ore in the deposit is found in the disseminated foot-wall ore which gives values of from 3% to 5% copper, the copper values for the whole ore-body, exclusive of horses, being approximately 1·9%. A thin selvage of blende separates the solid sulphide from the disseminated ore on the hanging wall side. Zinc, which averages approximately 3·8% for the whole ore-body, is more abundant on the hanging wall side

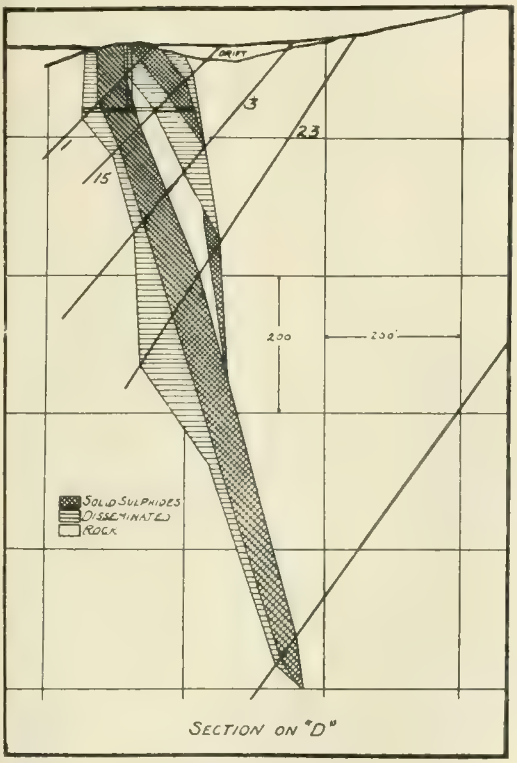


CLAIMS AT FLIN FLON LAKE

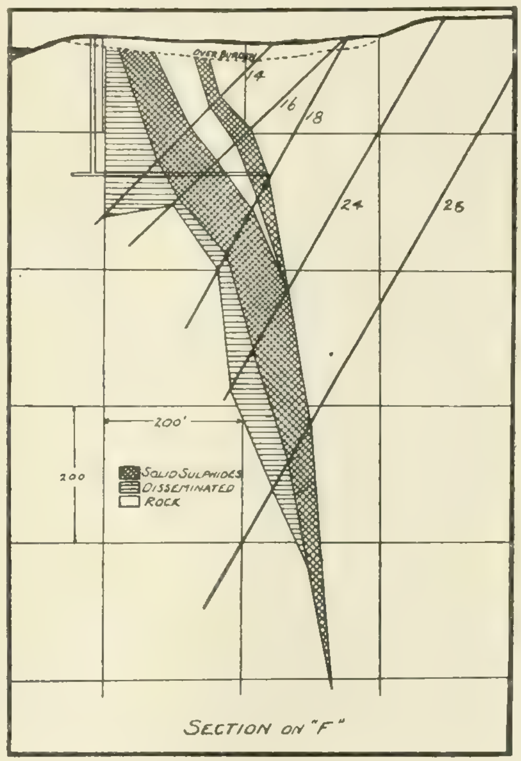
than elsewhere. While it might be expected that the gold would increase and the copper and zinc would decrease in depth, no indication of any such variation has been noted to the depth at which diamond-drilling has explored the property.

The ore-body has been formed by replacement of the rock which had already undergone intense mineralogical alteration during the shearing process. Where rock still remains (as in the disseminated-ore areas), its mineralogical composition would indicate that, in the main, the replaced rock was basic in character. The richest disseminated ore exposed by underground operations occurs in a typical chlorite schist. Bodies of quartz-porphyry occur, however, in close proximity to, and apparently within, the ore-body. At the end of the cross-cut of the No. 2 workings, quartz-porphyry forms the hanging wall in contact with the disseminated ore, the contact being practically vertical, while the dip of the rock in the ore-body is from 70° to 75°. In the disseminated ore immediately west of the solid sulphides in the east end of the same cross-cut, highly silicious bands, which represent either a silicious rock of

quartz-porphyry type or a subsequent infiltration of silica during the process of mineralization, are found. That silica has, to some extent at least, been associated with the replacement, is indicated by the character of the rock that has been exposed by surface workings immediately east of the horse. Here the sulphides have disappeared through weathering, and there is left a highly porous pumiceous silica rock which would appear to represent the result of silicious infiltration and replacement into a rock that was probably of an acid type originally. The bands of silicious rock in the disseminated ore in the cross-cut are of a similar character. The extent of shattering that the rock has undergone on shearing has been a factor of greater importance in facilitating replacement than has the actual chemical character of the rock itself.



SECTION NEAR NO. 2 SHAFT AS DETERMINED BY DIAMOND-DRILLING.



SECTION NEAR NO. 1 SHAFT AS DETERMINED BY DIAMOND DRILLING.

Replacement has taken place at a fairly high temperature and by hydrothermic processes; on the foot-wall particularly, the rock has been highly sericitized. In the chlorite schist, and in the sericite schist as well, irregular masses of talc are encountered in the underground workings. While such mineralogical changes indicate hydrothermal deposition, it is a remarkable feature in connection with the ore-body that the contact between solid sulphide and unmineralized, unchanged greenstone is so distinct, as is actually shown in the cross-cuts. While both quartz-porphyry and lamprophyre are rather closely associated with the deposit, there is no evidence to show that either volcanic phase is connected with the deposition of sulphides. The Kaminis granite and its offshoots seem to be the parent body from which the hot solutions and the vapours emanated. Throughout the district, sulphide bodies frequently occur in close association with quartz veins carrying gold; elsewhere, however, the sulphides are pyrite, with relatively small percentages of pyrrhotite and only occasional chalcopyrite. It would appear that during the later stages of plutonic activity now represented by the granite, the deposition of sulphides was closely connected with the precipitation of a gold-carrying quartz.

In the summer of 1915, the Mosher-Creighton party, which had been working north-east of Amisk Lake, was guided, by information, to the Flin-Flon Lake district and the Flin-Flon ore body was discovered. Some surface trenching was done in order to obtain an idea of the size of the ore-body, and late in the summer the claims were recorded. The news of the discovery and the importance of the ore-body were appreciated by other prospectors, and in a very short time the whole country in the vicinity of the deposit was staked.

During the winter of 1915-16, work was confined to surface sampling and cross-trenching. In March, 1916, two drills were at work, and by July of the same year 6,000 ft. of drilling had been done by New York and Boston interests, who, however, failed to reach an agreement with the owners. In the spring of 1917 certain Toronto interests entered into an agreement and diamond-drilling was continued throughout the year and until July, 1918. In all, 44 holes were drilled, representing a total linear footage of 25,664 ft. In March, 1920, an option on the property was taken by New York and Canadian interests, and since that date two shafts have been sunk over 500 ft. apart at the south and north

ends of the main horse The first shaft has reached a depth of 200 ft and at that depth there is 210 ft. of cross-cutting and approximately 100 ft. of driving southward. It was expected that the shaft would be entirely in the foot-wall, but at a depth of 135 ft. disseminated ore was encountered, and the shaft was continued in this ore to the 200 ft. level. When the cross-cutting is complete it will expose approximately 100 ft. of solid sulphides. No. 2 shaft was sunk to the 100 ft. level, and a cross-cut approximately 165 ft. long was made at this level. Sinking is now being continued to the 300 ft. level. (These figures refer to the situation as on September 10, 1920).

In operating the Flin-Flon property, a very large low-grade ore-body, far removed at present from transport facilities and industrial centres, there are many problems of major importance to be solved ; these refer in particular to water-power facilities, metallurgical processes, availability of fluxing material, fuel, and transport.

In order to develop water-power in sufficiently large quantity for operating a mine and smelter of 2,000 tons capacity at the Flin-Flon property, two sources of power are available. One of these is on the Churchill River at Island Falls, and is distant some 60 miles. A minimum production of 80,200 h.p. has been estimated for this fall. A nearer source of power, which will in all probability be adopted, is Birch Rapids on the Sturgeon-Weir River, distant 35 miles from the property in a westerly direction. The minimum under present conditions is 3,270 h.p., but this may be increased at will by tapping the Churchill River at Frog portage at the headwaters of the Sturgeon-Weir water system. At periods of high water there is at the present time a natural flow of surplus water from the Churchill River into the Sturgeon-Weir system and thence into the Saskatchewan River. It is estimated that the available power can be increased to 20,000 h.p. by thus utilizing part of the flow in the Churchill basin.

The disseminated ore will offer no special difficulties in treatment. Generally speaking, it will concentrate fairly readily and will be smelted in the reverberatory furnace. The solid sulphide (mixed pyrite-chalcopyrite-blende) ore will present greater difficulties to the metallurgist. Experimental work may discover a method of concentration whereby it may be possible to recover all or the major part of the zinc. If this is not feasible, it will doubtless be treated in the blast-furnace by pyritic smelting and only a limited proportion of the zinc recovered. There is a great field for experimental work on this ore in order to devise the most suitable and economical method of handling and smelting the solid sulphides. It will be necessary to add silica in considerable proportions and limestone in small amounts to the ore before smelting. Quartz veins that carry gold are more numerous on the west end of the mineral belt (Beaver Lake) and at its east end (Herb Lake) than elsewhere throughout the belt. The eastern district in particular is somewhat remote from the property. Apart from the gold-bearing veins there are silicious bodies of other types in the mineral belt ; in particular, quartz-porphyry flows, felsitic intrusions into the earlier volcanics, and sediments with a high silica content. In all probability quartz flux will be obtained in part from the lean bodies of greater extent and closer proximity to the deposit. Magnesian limestones of Ordovician age occur in quantity within ten miles of the ore-body. Pure limestones of Upper Devonian age are exposed at the north-west end of lake Winnipegosis. The use of this would necessitate a rail haul of 250 miles to the property.

Owing to the great distance from the eastern areas, Western coal will doubtless be utilized as fuel for the smelter. The success which has attended the use of pulverized coal in the experiments already carried out by various copper-smelting companies would indicate that powdered coal might be the cheapest and most available type of fuel for the smelter. It is not improbable, as well, that satisfactory electrical processes may be devised for an ore of this type many years before the deposit is exhausted. But at the present time development is more important than treatment.

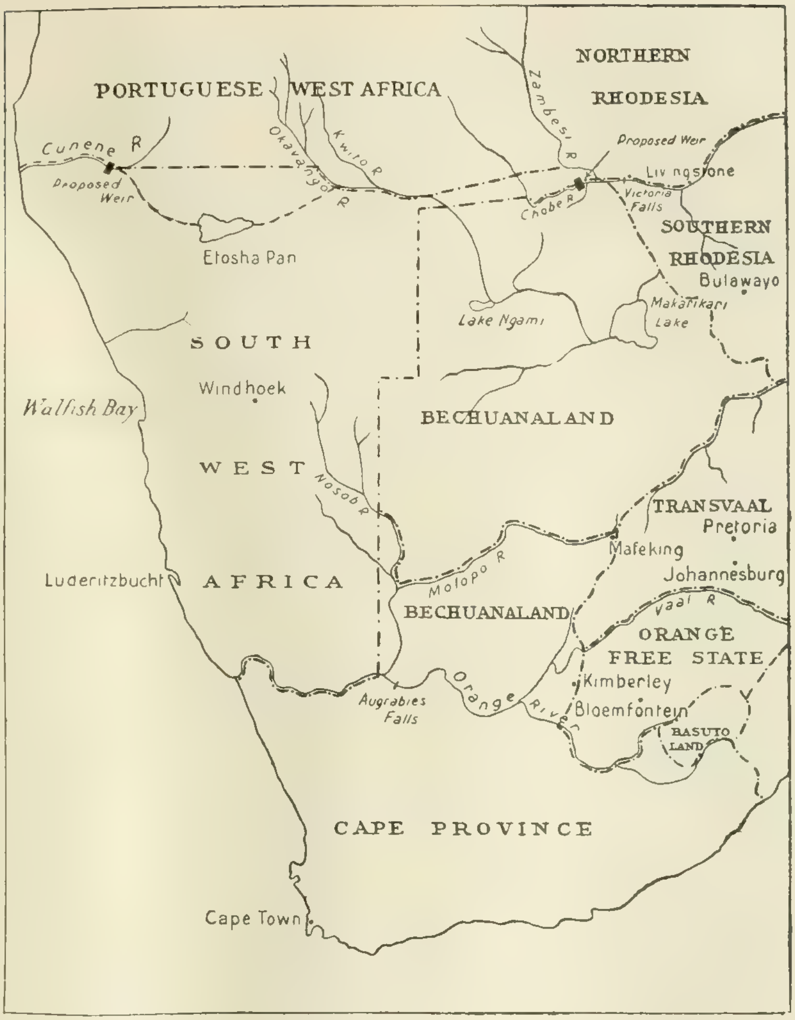
RECLAIMING THE KALAHARI DESERT.

Though the question of reclaiming the Kalahari Desert is not a mining problem, it is one of great direct interest to mining engineers, for if this and similar districts in Southern Africa were capable of supporting life a large accession would be made to the territories worth prospecting and development. Readers will probably be aware that Professor E. H. L. Schwarz has during the last year or two brought forward suggestions for the reclamation of these regions by bringing water into them so as to restore the old lakes. His scheme has already been discussed in the pages of the *South African Mining Journal*, *The Times*, and elsewhere. He has also published a book on the subject in Capetown. The Department of Mines and Industries of the Union of South Africa has taken an interest in the subject, and the *South African Journal of Industries*, published by this Department, has published an article by H. J. Choles in the January issue. We quote from this article herewith.

The question as to whether South Africa is drying up has often been asked and discussed. Whenever a drought occurs it invariably arises ; people refer to the reports of Le Vaillant, Lichtenstein, and other famous explorers of a century ago. They talk of the hippopotamus that infested the Karroo rivers, the rhinoceros, eland, and hartebeest that ranged through the forests along the banks, forests that have since given place to the prickly pear and Karroo bush ; and, pointing to the various circumstances that seem to indicate that South Africa is drier than it was a hundred years ago, they take sides in argument and endeavour to explain what is happening to the climate.

Two schools of opinion have thus evolved. According to the students of the one school, South Africa is, like other parts of the world, subject to cycles of dry and wet spells. The people who hold this view point to the literature of South Africa in the second quarter of the last century—roughly from 1827 to 1850—from which it appears that the conditions now prevailing are similar to those that prevailed at that time. They had then the same droughts, the same floods in the rivers, bringing down masses of mud instead of water, the same failure of harvests. So, it is argued, a spell of good years will come in due course, in accordance with the cycle of climatic changes.

The other school thinks differently. It maintains that, whether or no there be cycles in the weather, South Africa is actually drying up ; that gradually the sub-continent will become uninhabitable, the desert conditions begun in the Kalahari and in course of evolution in the Karroo, spreading eventually over the whole of South Africa, and driving the population to the relatively moist coastal belt, which on the south and east will offer the only areas fit for human habitation. Of this school of thought Professor E. H. L. Schwarz, of the Rhodes University College, Grahams-



MAP EXPLAINING PROFESSOR SCHWARZ'S PROPOSALS FOR RECLAIMING THE KALAHARI DESERT.

town, is one of the most able exponents, but his pessimism is relieved by the enunciation of a remedial scheme which, he claims, will not only stabilize the rainfall, thus rendering it of real value at all times to farming operations, but will increase it, and will also turn the Kalahari and the Karroo into rich regions capable of supporting a large farming population.

Schwarz's scheme is based on the fact that rainfall cannot occur without prior evaporation. The precipitation of moisture does not necessarily occur just at the spot where the moisture was taken up into the atmosphere, that is to say, over the sea or over a lake. It may occur a long distance away. Precipitation, or rainfall, depends upon the mountains or the changes in atmospheric temperature which are encountered by the current of moisture-laden air. Nowadays in South Africa rains come almost entirely from the evaporation that takes place over the sea. Unfortunately, however, as soon as the moisture-laden winds from the ocean reach the land, they encounter high mountains all along the coast; the moisture is precipitated as rain, and when the winds pass over the mountains they are almost dry; there is little rain for the interior. The ocean currents along the coasts, too, have an important influence upon the rainfall. It happens that the current along the east and south-east coast is warm, while that along the west coast is cold. The consequence is that the air which blows off the sea on to the land on the east arrives warmer than the land, and therefore, becoming suddenly chilled, lets its moisture fall; while the air blowing on to the land on the west comes colder than the land, it warms up, and is not only able to hold its moisture, but craves additional moisture to satisfy its increased power of absorbing water-vapour, in other words, it tends to dry up the land instead of supplying it with rain. The consequences are that, on the east coast, the coastal belt of Natal and Zululand, for instance, there is a good rainfall and a perennially moist atmosphere; while on the west coast there are hopeless deserts.

Evidence of the reason for thinking that these conditions are not stable, and that things are changing for the worse is found on studying the ancient lakes of South Africa. These are now almost dry; at best they are

swamps. And it appears that a proportion of the rainfall is due to the evaporation that is still going on from the remains of these lakes. Soon the last of these swamps will disappear, the desert will advance over the beds of these ancient lakes, and South Africa will be thrown back upon the sea as the sole source of its rainfall. Ages ago, and until quite recently, South Africa possessed three great lakes, covering some 50,000 square miles, an area equal to that of the Orange Free State, or to the three largest existing lakes in the Continent of Africa, or again to more than half the area of the five great lakes of North America combined (93,000 square miles). These three lakes are: Greater Ngami, covering 30,000 square miles; Makarikari, covering 15,000 square miles; and Etosha Pan, covering 5,000 square miles. These lakes have disappeared. The huge depressions which in a former age the waters occupied can still be traced; a few reedy, swampy "pans" are all that is left of these former inland seas.

In those days, as in Central Africa now, South Africa was independent of the seas for its rainfall; the lakes, with their great evaporative surfaces, provided the country with its own circulatory system, and South Africa, from the Zambesi and Kunene even down to Capetown, was like British East Africa in the luxuriance of its vegetation, its rich fauna, its ample rainfall, which with the hot sun sustained and encouraged all forms of tropical life. Then it was a country of great rivers, whereas now, the big rivers, on which the fertility of half the Continent of Africa depends, are in danger of extinction. The reason why the rivers are disappearing and the lakes have vanished is given by Professor Schwarz as headstream erosion, otherwise, the means by which the short, rapid coast streams eat back through the heart of the coastal mountains and tap the waters of the inland system, whose waters are more sluggish. Headstream erosion, again, has tapped the Zambesi basin, from the east, and has diverted its waters, which once flowed south-west, through the Kalahari, and has turned it into a desert. In the Transvaal, the Komati River is stealing into the territory of the Vaal River, the Olifants River draining inland as far as Pretoria, and the Limpopo reaching back even to the outskirts of the Kalahari. Further north, the Sabi River has pierced the Melsetter barrier-range and drains the whole country from Bulawayo to Salisbury; finally, the Zambesi sends back its tentacles almost to the west coast. Every one of these rivers started originally at the coastal rampart and has eaten back by headstream erosion. The waters inside the barrier-ranges once flowed toward central South Africa, and made the central depression a land of running rivers and of great fertility.

The continent is almost entirely girdled by mountains or tablelands that begin to rise sometimes actually at the coast, in other places at but a short distance from the seaboard. Professor Schwarz shows how the courses of these rivers have been changed; how the Congo River, which now empties itself into the Atlantic Ocean on the west coast, in ages past flowed steadily northward, through luxuriant country which is now the Sahara Desert, into the Mediterranean.

South of the Zambesi, the greatest South African river of the present time is the Orange. It rises in Basutoland and, after taking a north-westerly course, it turns, and for the last 500 or 600 miles its general direction is westward. Taking a line northward to the Zambesi, to the Victoria Falls, and then a line across the continent to the mouth of the Kunene River, crossing on the way the Chobe and Okavango Rivers, it will be seen that there is an area of roughly 600,000 square miles without a river worthy of the name, a land of successive deserts, the true "Thirstland of South Africa." It is this area that Professor Schwarz's scheme is expected first to redeem by irrigation.

Just as Egypt has still its Nile and the Sahara once had its Congo, so in times past South Africa had a great central river, which Professor Schwarz calls the Proto-Orange. This river rose in the highlands about Tanganyika, and is now called the Loangwe River. This flows south-west and joins the Zambesi near Zumbo; thence it originally flowed up the channel of the Zambesi to Wankie, then across to the Soa Pan or Makarikari, to the Molopo River and out to sea by the Orange River. The Proto-Orange fed and drained the Central South African lakes, Ngami and Makarikari. It failed as a river south of these lakes owing to the capture of its headwaters by the headstream erosion process to which reference has been made.

Livingstone's idea of how the waters were turned northward was that a "cataclysm of nature" had opened the rent of the Victoria Falls and drained all the waters into the cleft. R. S. Fairbridge states that what caused the diversion was a shallow bar in the river formed by a storm-carried drift of reeds and brush.

The watershed between the Zambesi and the Orange Rivers is so flat, west of the Bulawayo—Johannesburg railway, that when there are heavy rains to the north, the surplus water drains south into the Kalahari, and when there are heavy rains to the south, the surplus runs north into the Zambesi. The long, wide, shallow, reedy depression in which this takes place is called the Tamalukan River, and about three generations ago a very wet season in the north washed a great bank of reeds and rubbish into the southern part of the Tamalukan, where it stuck, and thus prevented any more water draining south toward the Orange River. This explanation corresponds with evidence gleaned from Bushmen, from which it appears that prior to about 1820 the Soa Pan (a remnant of the old Makarikari Lake) always contained water, in which hippopotamus, crocodiles, and fish abounded. But suddenly, they say, the waters from Ngami ceased to flow; the lake dried up, and the dead fish and animals were devoured by vultures. Professor Schwarz points out that these statements correspond with the descriptions of the country before and after 1820. Before that year Le Vaillant, Van Reenen, and others described the country as being like British East Africa; directly after 1820 Thompson described terrible droughts, and thereafter all travellers tell the same tale with increasing emphasis on the droughts.

Professor Schwarz proceeds to consider the western side of the continent, in particular the Etosha Pan—the remnant of a permanent lake—and the Kunene and Okavango Rivers. These rivers, together with the Zambesi and several of the headstreams of the Congo, rise in the Angola Highlands. To the south lies Ovamboland, a plain some 70,000 square miles in extent. In former times this plain used to be flooded annually from the Kunene and Okavango Rivers. Nowadays not half of this area is flooded, and the portion receiving the flood-waters is becoming smaller every year. To the south again of Ovamboland lies the Etosha Pan, which used to be a permanent sheet of water fed by the Kunene River, which, instead of turning westward and discharging itself into the Atlantic, as it now does, continued on its southerly course and flowed into the Etosha Lake, which then drained off eastward into the Okavango. Here, again, the headstream erosion of a coastal river has beheaded the Kunene, drawing its waters westwards. Professor Schwarz points out that, in the times when the whole of Ovamboland was periodically flooded, the huge evaporative surface thus produced added

very considerably to the rainfall of Angola, which must, therefore, be becoming steadily drier, with effects upon the Kunene, the Okavango, the Zambesi, and to some extent the Congo. His scheme, he claims, will restore the rainfalls of Angola and so maintain and perhaps enhance the flow of these rivers.

As already stated, Professor Schwarz ascribes the aridity and semi-aridity that characterizes parts of South Africa to the non-existence of a rainfall circulatory system independent of the ocean, confined within the coastal rampart of mountains and high land, and having as its source large sheets of water in Central South Africa to serve as evaporative surfaces. In other words, he says the disappearance of the 50,000 square miles of lakes which formerly constituted the main source of South Africa's rainfall system has led to the present state of aridity. His proposal therefore is to take steps to restore the three great lakes. To do this two weirs are necessary; one on the Kunene River, at a spot which will result in its being diverted into its old flood channels; the other at the Nduala Rapids, on the Chobe River, which will then tend to flow south instead of north. Professor Schwarz does not in either case suggest that masonry weirs be built to begin with. He thinks all that is needful at present is a weir built of piles and filled in with rubble and branches. Weirs of this description will create the necessary diversion, and later it can be ascertained what permanent works are necessary really to perpetuate the diversion. Professor Schwarz is convinced that the diverted waters of the two rivers will find their ancient courses, clearing them out wherever sand has drifted into them and has filled them up.

It remains to describe the effects which the damming of the Kunene and Chobe Rivers would have upon South Africa. Given the southward diversion of the waters of the Kunene and Chobe into their ancient beds, the first results would be the filling of the old lake beds—the Etosha, the Ngami, and the Makarikari—not to their ancient limits, but to an extent sufficient to create large evaporation surfaces for the improvement of the South African rainfall. From the Etosha the water would pass eastward along ancient water-courses until it poured into the Okavango. The Chobe weir would throw the waters of these two rivers southwards, resulting in the re-establishment of the Ngami Lake, from which again the Makarikari would fill. When these lakes are full, the probability is that the overflow water would reach the Molopo, and its course to the Orange and the sea would then be assured. This conclusion cannot, however, said to be certain, as survey data are not available.

Professor Schwarz says that the water-vapour from the lakes will permeate the whole of South Africa within the ledge of the coastal mountains. The inland slopes of these mountains will give as copious springs as the seaward slopes; these will gather into rivers and flow into the Karroo, as they did till quite recently. By restoring the moisture in the air to the amount that existed in it before 1820, it is claimed that South Africa will reap the following benefits among others: (1) steady rains instead of sudden outbursts; (2) clearer water; (3) no veld erosion; (4) protection of surface by continuous vegetation; (5) no brak; (6) no need to irrigate, except for special crops. The climate over the whole of South Africa will be rendered cooler by day and warmer by night, the rainfall will increase, even over the Kalahari Desert, which will be converted into a reasonably habitable country, droughts and deluges will disappear, rivers now dry for the greater part of the year will develop a perennial flow, springs will not fail, forests will spring up, and the whole country will become again like British East Africa is to-day, though possibly with a lower temperature. The restoration of the lakes will increase the fertility of the land through which the re-established river or rivers will flow, and large blocks of land, capable of supporting thousands of settlers, will become available for irrigation. The Kalahari soils are rich and they only need water to render them highly productive.

PETROLEUM PRODUCTION IN VENEZUELA.

In the *Engineering and Mining Journal* for February 19 and 26, A. H. Redfield, of the United States Geological Survey, writes on the present petroleum activities in Venezuela and of the prospects of the industry.

There are two oil-bearing districts in Venezuela. One includes the basin of the arm of the sea known as Lake Maracaibo, and the second comprises the shores of the Gulf of Paria from the northern part of the Orinoco delta to the promontory of Paria. The total area of the Maracaibo district is 27,500 square miles; that of the Paria region is 2,100 square miles. Only a small part of the oilfields about Lake Maracaibo has been proved by drilling. The Paria district has been celebrated for years for the production of asphalt, but no oil in commercial quantities has yet been extracted there.

The geology of the Maracaibo oil region, as far as it is known, presents similarities of stratigraphy and structure to the Colombian oilfields, particularly those of the Magdalena-Santander district, to which it is geographically contiguous. The mountains of the Maracaibo district are apparently a topographic and a geologic continuation of the Colombian Andes. As in Colombia, the manifestations of oil are most abundant in the Cretaceous sandstones and limestones and in the Tertiary, especially in a "coal series," the Cerro de Oro terrane, ascribed to the Miocene, though its Colombian counterpart has been considered Oligocene. An equally striking similarity of stratigraphy can be traced between the formation of the Maracaibo and Paria districts of Venezuela, and also between the formations of the Paria district of Venezuela and those of Trinidad. A continuity of structure is apparent throughout the three regions. The minor anticline folds with which the geosynclinal basin of Lake Maracaibo is wrinkled bear about N. 61° E. In the Paria region the prevailing structure is one of minor folds and faults with a general bearing of N. 75° E.

The Venezuelan oil is prevailingly asphaltic. Discoveries of paraffin-base oils have been reported, but the petroleum obtained from the wells so far drilled has revealed on analysis an asphalt base. So too, though reports of light-gravity oils have been published, the oils actually extracted in recent years have ranged from 0·928 to 1·02 specific gravity. Not more than 3% of petrol or 7% of kerosene has been obtained from Venezuelan petroleum in refinery practice.

The commercial production of petroleum in Venezuela began in 1917. The accompanying table gives the production, the amount refined, and the exports of crude oil.

	Production		Refined at San Lorenzo		Exports to Curaçao	
	Metric Tons	Barrels	Metric Tons	Barrels	Metric Tons	Barrels
1917 ...	18,255	119,734	8,871	58,185	9,383	61,541
1918 ..	50,710	332,607	24,648	161,666	25,298	172,489
1919 ..	64,628	423,895	54,000	354,000	10,600	60,522

No phenomenal yields of petroleum have been obtained from any of the seven wells that were in active

production in 1919. The highest known output of the Zumbador well, in the Mene Grande field, was 229 86 barrels per day. Commercial production in Venezuela has been attained only by the Caribbean Petroleum Co. A Venezuelan company, under a title granted Sept. 3, 1878, produced and sold locally for many years small quantities of kerosene refined by crude methods from oil won in shallow wells in the municipality of Rubio, District of Junin, State of Táchira, but little is known of its activities, which have been conducted on a small scale. Its production from 1905 to 1907 averaged 50 metric tons a year. No later statistics of its output are at hand.

Map of Venezuela.

The production of asphalt in Venezuela by companies in recent years is as follows:

		1917 Metric Tons	1918 Metric Tons	1919 Metric Tons
New York & Bermudez Co.	Guanoco	52,991	46,453	45,932
South American Company	State of Zulia	72	50	—
Cia. Anonima Minerales Petroliferos Riopauji	State of Trujillo	1,009	—	—
	Totals	54,072	46,503	45,932

At first the larger part of the Venezuelan crude oil was shipped in barges to the Royal Dutch refinery on the Island of Curaçao, but in 1919 the plant at San Lorenzo took over four-fifths of the output of the Mene Grande wells. The San Lorenzo refinery is designed to supply only the Venezuelan trade. Exports to the foreign markets are made from Curaçao refinery.

Various estimates have been made of the reserves of petroleum in Venezuela. These range from 150,000,000 to 250,000,000 metric tons, based on estimates of the probable oil-bearing territory and the richness of the oil sands. These estimates will undoubtedly have to be reduced in the light of the experiences of the producing companies. Of the 1,028 areas of 500 hectares each, selected by the Caribbean Petroleum Co. in 1913 for exploration and possible development, 767 areas had been renounced to the Venezuelan government by December 31, 1919, after examination or drilling. It was expected that more would be renounced in 1920 after detailed geologic examinations. On this basis the estimated reserves of available petroleum may have to be reduced to 40,000,000 or 60,000,000 metric tons Altogether, Venezuela has not lived up to expectations

No estimates are available as to reserves of asphalt. The deposits of Bermudez Lake give evidence of constant renewal, and other asphalt lakes exist also, both in the east and in the west, which, however, have not been commercially developed.

The only active producer of petroleum in Venezuela previous to 1919 was the Caribbean Petroleum Co., of Camden, New Jersey. The company, after a thorough exploration by a party of thirty-five geologists, headed by Ralph Arnold, selected in 1913, for preliminary work of development, 1,028 areas of 500 hectares each, situated on both sides of Lake Maracaibo. The principal holdings of the Caribbean Petroleum Co. are in the Mene Grande field, seventy miles east of Maracaibo and sixteen miles inland from San Lorenzo; in the Miranda district, east of Lake Maracaibo; at Perijá, fifty miles west of the city of Maracaibo; and in the Santa Cruz de Mara district. Drilling in the Mene Grande field began in January, 1914. The first well drilled struck oil at a depth of 390 ft. and produced about 10 barrels a day. In the next two years, five other wells were sunk ranging from 600 to 1,700 ft. in depth. Oil was found in all; most of the wells had to be capped. The following statement shows the condition of the productive wells in the Mene Grande field in the fall of 1920:

Well	Drld.	Ft.	Initial Production Metric Tons	Present Conditions
Zumacaya No. 1 ...	1915	583	40	Capped
Zumaque No. 1 ...	1914	390	40	Capped
Zumaya No. 1 ...	1914	1,667	400	Producing
Zumba No. 1 ...	1915	882	250	Choked with sand
Zumbador No. 1 ...	1915	869	300	Producing
Zumbel No. 1	1915	552	400	Choked with sand
Zo. No. 1 .	1918	797	40	Dammed with cement to exclude water
Zumaque No. 2 ...	1919	903	100	Dammed with clay and cement to exclude water

The output by wells in this field has been as follows:

	1917 Metric Tons	1918 Metric Tons	1919 Metric Tons	Jan.-June, 1920 Metric Tons
Zumbador No. 1	10,240	26,103	36,862	23,102
Zumba No. 1	8,015	11,548	6,592	4,522
Zumbel No 1			336	652
Zumaque No. 2			102	15
Zumacaya No. 1	—		528	76
Zumaya No 1			19,068	842
Zo. No. 1	—	3,059	1,141	76
Totals ...	18,255	50,710	64,628	29,285

Work was started by this company in 1917 in the Santa Isabel field in the district of Miranda, State of Zulia, and drilling was continued throughout 1920. In the Perijá field the first well of the Caribbean Petroleum Co., drilled in 1915, showed oil in considerable quantities at 1,227 ft., and was shut in. Two more wells started in 1916 were completed in 1917 and 1918 respectively, without satisfactory results. In 1919 one well was drilled to a depth of 2,235 ft. without success. This final failure induced the company to renounce many of its holdings in the Perijá field. Development of the Mara fields was begun in 1917. Three wells were drilled in 1917 near Iniciarte, to depths respectively of 900 ft., 811 ft., and 2,018 ft. Shows of oil were obtained, but not in commercial quantity. When a well begun

in May, 1918, was carried to 1,980 ft. without a commercial yield of oil, the company renounced its concession to a number of areas in this field. Three wells in the Cachirí field were drilled in 1917 down to basalt, to depths of 1,950 ft., 430 ft., and 736 ft. respectively. No commercial quantities of oil were found. A well drilled in 1918 encountered igneous rock at 745 ft., and was abandoned. In the La Sierrita field, in the district of Mara, a well was started in October, 1919. Despite delay occasioned by a lack of water, requiring the laying of a pipe-line to the Ciénega de Sinamaica, twelve miles distant, the well had been carried by the end of the year to 1,146 ft. through clay, shale, and sand. Drilling was continued during 1920.

The Venezuelan Oil Concessions, Ltd., of London, holds a concession covering 8,128 acres in the district of Maracaibo, on the west side of the lake, and in the district of Bolívar, on the east side of the lake. Development of the Bolívar area began late in 1913, with the drilling of wells at La Rosa and Santa Rita. The Santa Rita well was drilled to a depth of 1,600 ft. without striking oil, and was then abandoned. In the La Roca well, oil sand was met at a depth of 800 ft.; and at a depth of 1,500 ft. a sand giving oil of 30° B. was struck. A great quantity was given at first; but after ten days the output had decreased to 10 barrels a day. No attempt was made to pump the well, which was abandoned. The company fought a losing fight with the mosquitos, which decimated its workers with malarial diseases. The drilling system originally adopted proved unsatisfactory, and new equipment was ordered in the United States. The outbreak of the War prevented the delivery of this equipment. Nevertheless in the next three years five more wells were drilled, ranging in depth from 600 ft. to 1,800 ft., and spread over a wide area. Oil is said to have been found in five of the seven wells, of which those near Santa Barbara are believed to be of commercial value. Drilling in the Barroso field was started in June, 1918; but the well was discontinued after an accident to the casing. A second well begun in the latter half of that year was abandoned at 536 ft. In the spring of 1920 there was practically no activity in the Bolívar holdings of the Venezuelan Oil Concessions, Ltd.

The principal holdings of the Colon Development Co., of London, are in the Colon district, State of Zulia, especially in the vicinity of El Cubo, near the Colombian border, 100 miles south-west of Encontrados, and are contiguous to the Barco concession in the State of Santander del Norte, Colombia. The geologic exploration and the subsequent development of the Colon field were considerably hindered by the depredations of the Motilones Indians, necessitating an armed guard about the field camps and drilling machinery day and night. Drilling began early in 1914. The first well was abandoned at a depth of 700 ft. The second well, on the Rio Oro, reached over 1,000 ft., giving an initial output of 200 barrels a day of light-gravity oil. Three wells were drilled along the Rio Tarra, the deepest to 2,362 ft. A sixth well was carried to 328 ft. during 1919. The Colon Development Co. had drilled up to May 1, 1920, six wells, as described. Three of these were found productive and capped.

The British Controlled Oilfields, Ltd., is operating the Buchivacoa concession of 3,000 square miles in the State of Falcón, acquired from the Venezuelan-Falcón Oil Syndicate, Ltd. The property is said to contain a sharp, narrow anticline traceable for fifty miles from north-east to south-west. Toward the west, the anticline pitches south-west and shows recurring dome structures. Seepages of a light oil are numerous. Development is taking place in two main divisions. In the western division, of which the field headquarters are at Altagracia, two wells have been drilled. Both the rotary and the cable systems of drilling have been used. The first well gave a small quantity of oil at a depth of 1,800 ft.; the second showed oil at a depth of 1,000 ft. Oil, when met in commercial quantities, will be transported by a pipe-line to be built to Altagracia or to the Caribbean coast, fifty miles to the north. The field headquarters of the eastern division are at Dabajuro, eight miles south of the Caribbean coast; and the drilling camp is twenty-four miles to the south-east. Three standard drill rigs were under construction at the end of August, 1920.

The following American companies are developing in the Maracaibo district: The Maracaibo Oil Exploration Co., of New York, organized in 1919; the Sun Co., of Philadelphia; the Venezuelan Oilfields, Ltd., organized under the laws of the State of Delaware. One English company, the North Venezuelan Petroleum Co., Ltd., began exploration in September, 1920, the principal deposits lying in the vicinity of Píritu.

The petroleum activities described in the foregoing paragraphs are all in the Maracaibo basin. It remains to mention the work done in the Paria district. This district comprises the coastal belt of the Gulf of Paria from the northern part of the Orinoco delta to the peninsula of Paria, an area roughly seventy miles long and thirty miles wide. To this may be added the coastal belt and outlying islands from the peninsula of Paria as far west as Barcelona, where oil seepages occur in local areas. The oldest rocks exposed in the Paria district are the pre-Cambrian gneisses and schists which form the backbone of the peninsula of Paria. In the metamorphosed sediments which accompany these a few Ordovician fossils have been found; but in general the oldest determinable rocks of this district are Cretaceous.

The most striking evidence of the occurrence of petroliferous formations in eastern Venezuela is the famous Bermudez asphalt lake, situated near the town of Guanoco, three miles above the confluence of the Guanoco and San Juan rivers. The lake is twenty-five miles from the Gulf of Paria and 105 miles due west of the equally renowned Pitch Lake on the island of Trinidad. The Bermudez Lake is formed by the overflow of several oil springs on a swamp. It is about 1,110 acres in extent, and varies from 1·9 ft. in thinner parts to 20 ft. in thickness near the seeps. The lake is believed to consist of the residues of an asphalt-base petroleum, the lighter oils having been distilled away. The flows are composed of alternate layers of asphalt and fine sand. Crusts of slag and burned asphalt point to fires caused by Indians or by the natural ignition of gases emanating from the lake. The lake is overgrown by jungle and covered with water. Blowholes of gas occasionally occur. Water accompanies them, frequently rather warm and highly impregnated with sulphuric acid. The asphalt of the lake shows upon analysis 64·39% of bitumen soluble in carbon disulphide, 30% of water, 2·08% of inorganic matter, and 3·53% of organic matter. After extracting the water the remainder gives 96% of bitumen and 2 to 5% of earthy matter, with a loss of 2%. The lake is owned and exploited by the New York & Bermudez Co., a subsidiary of the General Asphalt Co. of Philadelphia, which is also owner of the Pitch Lake of Trinidad. In extracting the asphalt, a dam of slag and waste is built to exclude water, and the water within the enclosed area pumped out. The asphalt is dug out by hand and loaded into cars. These are hauled by cable to the light railroad, which conveys it eight miles to Guanoco. A refinery with a capacity of fifty metric tons a day expels the water. The refined pro-

duct is then ready to be exported. The United States takes practically all of the shipments of Bermudez asphalt, except occasional small exports to Trinidad.

A second pitch lake occurs in the Pedernales field, at La Brea, on the north-west coast of the island of Capuré. The lake is half a mile in length and 100 to 200 yards across. It is fed by several active oil springs and one asphalt cone. About three-fourths of a mile south of the main deposit are two small cones; additional deposits occur two miles to the north-east. Asphalt deposits are also found on the island of Plata. The Pedernales asphalt deposits were exploited by a German firm for a short time in 1902. The ruins of the German refinery are still visible one mile from Pedernales. Mud volcanoes are reported near Bermudez Lake and the neighbourhood of Maturín.

The New York & Bermudez Co. began drilling for oil in 1913. Wells had been drilled on all areas by June of that year. The lands on the peninsula of Paria were soon decided to be not commercially valuable, and were abandoned. Seven wells, ranging from 200 to 1,100 ft. in depth, were drilled on Pedernales Island. Difficulties with heaving sands, soft mud, and gas pressure necessitated several changes in the method of drilling. Traces of oil were found, but none in commercial quantity. Several wells were sunk in the Guanoco area, near Bermudez Lake, ranging in depth from 200 to 4,200 ft. In some a heavy oil of 1·020 specific gravity, almost an asphalt, was found. Such an oil would have to be heated in order to be pumped. No oil of commercial value was obtained. Much geological investigation has been done to find the oil, which is believed to exist here in large quantities.

The Caribbean Petroleum Co., of Philadelphia, has been drilling in the Chapapotal field, fourteen miles north-west of Maturín, in the State of Monagas, near Chaguaramal, and in the Guanipa field. The field headquarters of the company are at Guanoco. Two wells were drilled in 1918 in the Chapapotal field. The first was abandoned at a depth of 208 ft. after an accident. The second was carried to a depth of 3,231 ft. Asphalt was encountered but no fluid oil in commercial quantity. The exploration work was nearly completed at the end of 1919, with results that do not appear to indicate a commercial value for the deposits. Further exploration work will probably be undertaken.

The Petroleums of Borneo.—At the meeting of the Institution of Petroleum Technologists held on March 15, James Kewley read a paper describing the characteristics of the petroleums obtained in Borneo.

The petroleum industry of the East Indies is of comparatively recent growth, dating back in the case of Borneo to not earlier than 1897. The production of the Koetei fields, which were first developed, has steadily increased and has been supplemented by that of areas developed at later dates. Indications of petroleum had long been known in Borneo and the other islands of the East Indian archipelago. As far back as 1853 Motley noticed oil occurrences in the island of Labuan. In 1863 Menten found also seepages in the island of Tarakan, on the east coast. In 1866 a shallow well was drilled in Labuan which gave a small flow of oil for thirteen years at least. Collingwood, in 1868, described a petroleum spring in British North Borneo, and stated that others were known. About 1887 three wells were in existence on the Klias peninsula on the north of Brunei Bay, and these gave oil in very small quantities. Menten, in 1888, obtained oil and coal concessions near the mouth of the Mahakam River, which concessions give to day the most important output. In 1891 he obtained further concessions near Balik Papan, then a tiny fishing village, now a thriving refinery centre. Further indications are found in the Bolongan area in West Borneo, Sarawak, and elsewhere. In 1897 the first well was put down at Sanga Sanga, and oil was found at 58 metres In August, 1898, the Nederlandsch Indische Industrie en Handel Maatschappij, and about the same period several other companies, for instance, the Bombay-Burmah Trading Co. in British Borneo, and the Koetei Exploration Co. in East Borneo, began operations. In 1901 the Royal Dutch began to drill in Koetei, and the East Borneo Co. a little later. The production of these fields rapidly increased, and had already reached a figure of nearly 60,000 tons in 1900. At the present day the production of Borneo is about 4,000 tons per day.

There are at present three important producing areas in Borneo: (1) the Koetei area, extending from the mouth of the Mahakam River southwards toward Balik Papan Bay; (2) the Tarakan field, situated on the island of Tarakan on the east coast, about 80 miles south of the British North Borneo frontier; (3) the Miri area, on the west coast in Sarawak, about 150 miles south of Brunei Bay. These three areas differ to some extent geologically, and considerably in respect to the types of oil they yield

The oil-bearing rocks of the Koetei area are of Pliocene and Miocene age. They consist of Pliocene sands, gravels, and clays laid down under delta conditions, the sands being dominant and the clays subordinate. Lignites containing a high water content (25%) are of frequent occurrence, as is the case in the Tarakan area also. Boulders of coal of lower water content from the lower Koetei formation also occur. This series lies unconformably on the Miocene, which is made up of interbedded clays and sands, with frequent coal beds lenticular in form, all laid down under delta conditions. Below these strata is found the greensand formation, which consists of glauconite sands with interbedded foraminifera limestones, the age of which has not yet been definitely determined, but which are probably early Miocene. Below these, again, a marl which is probably of Eocene age, similar to that found in North Borneo. The Miocene and Pliocene were laid down under delta conditions, the material having been brought down by large rivers such as the existing Mahakam, which flowed down from the central massif of Borneo. This massif, which is exposed in the south-west of Borneo, and which almost certainly extends under the surface strata through the centre of the island, is of igneous rock. On its flanks the Miocene and Pliocene deposits were laid down. Subsequent lateral pressure in a north-west to south-east direction gave rise to a series of folds in this area running north-east to south-west, roughly parallel to the Macassar Straits. These folds appear as the well-marked anticlines of Sanga Sanga and Palarang. The general folding process must have begun before the Pliocene rocks with lignites were completely laid down, so that the tops of the folds evidently appeared as islands in the Pliocene sea, and on being denuded supplied in part the material which was deposited in the tectonic troughs. The sinking of these troughs and the filling in of the same must have taken place at about the same rate, as indicated by the uniformity of the strata traversed by the wells in the Tarakan field. A further subsidiary folding was caused by lateral pressure in a north-east and south-west direction, which, however, was not so marked, so that the anticlines appear as very elongated domes. On these elongated domes the oilfields were developed.

In the Koetei fields three distinct types of crude oil are found, namely, heavy asphalt oils in the upper strata,

light asphalt oils at greater depths, and paraffin wax oils at still greater depths.

The structure of the Tarakan field is that of a system of two domes with a depression in between, the major axes of which run in a north-south direction. In this area, which is also of delta formation, Pliocene sand predominates. The field is developed in part of the delta which was nearer the coast and where consequently sands predominate, the interlying clays being not so well marked. Pliocene coals, or rather lignites, often containing boulders of older coal from the late Miocene formation, are frequent. The oil from this field is markedly uniform in composition.

The Miri field lies on the west coast of Borneo. The geological structure here is not yet so well known as that of the two fields described above. There is a well-marked anticline, the eastern wing being very much the steeper. The oil is drawn from the western wing. The strata here are also of Miocene age, and coals are absent. The oils of the Miri field are fairly uniform in character, but differ fundamentally from those of the Koetei and Tarakan fields.

The crude oils of Koetei fall into three main classes: (*a*) heavy asphalt-base crude oils; (*b*) light asphalt-base crude oils; (*c*) light paraffin-base crude oils. The oils have one character which sharply differentiates them from practically all other crudes so far known. The specific gravities of the distillates are much higher than those of corresponding distillates from most other crudes. The same applies to the refractive indices. These characters, and the inability of kerosenes produced from these crudes to burn in any ordinary lamp without arrangements for an extra supply of air, were naturally soon discovered (Ragosin, *Pet. Rev.*, vol. 8, 1903, p. 59). The reason for this is the presence of unusually large proportions of aromatic hydrocarbons in these oils. The occurrence of aromatic hydrocarbons in crude oils has long been known. In fact, aromatic hydrocarbons have been found in small quantities in most crude oils, but seldom to an extent greater than 15%, usually to a much less extent. Examinations of Koetei oils have shown that they contain extraordinary quantities of aromatic hydrocarbons, amounting to as much as 40% consisting chiefly of benzine, toluene, and meta-xylene.

It is interesting to note that the high aromatic content of Koetei oils, which some years ago rendered them of comparatively low value, eventually rendered these oils of the greatest importance to the British Empire as a source of toluene.

The consideration of a few generalizations drawn from a study of the occurrence and characters of the crude oils of Borneo, particularly of the Koetei field, may be found to throw a little light on the origin of petroleum. The crude oils of the Koetei field were either developed in situ or else they migrated from some mother rock into their present reservoirs. If these oils were found in situ, then they must be of vegetable origin, as there is no indication in the sands and coals of sufficient animal matter to have yielded such quantities of oil. Further, had they developed in situ, they must have arisen either from the coal or from the vegetable matter which formed the coal. Experience does not lead one to expect that they have been formed from the coal, and the change of vegetation, partly into coal, partly into oil, is equally contrary to experience. The other view, that the oils migrated into their present position, is much more probable, and is supported by certain evidence afforded by the differences in composition of the crude oil from different horizons. Conditions advantageous to migration exist in the Koetei and Tarakan fields. In the former, clays and sands alternate, but the layers are discontinuous owing to their formation under delta conditions, so that a zigzag course is open to the oil migrating upwards, there being, however, many opportunities for retaining portions of the oil under impervious clays *en route*. A possible source of the oil is to be found in the foraminifera limestone (which is a shallow water deposit accumulated quickly) of the early Miocene, or possibly in the marl formation of the underlying Eocene. It is possible that as the oil migrated upwards, coming into contact with or passing through the coal beds, some chemical interaction between the oil and the coal may have taken place. One might expect, therefore, differences in composition of the oils which have been arrested in their upward course by local obstacles at different horizons. This is, indeed, undoubtedly the case. The oil found at the greatest depths so far drilled is rich in paraffin wax. The oils found at higher levels are poorer in paraffin and richer in aromatic and asphaltic constituents. The early Miocene greensand formation, which underlies the Koetei petroliferous formations, has not yet been penetrated by borings, but it is found outcropping in the Palarang anticline, which runs parallel to that of Sanga Sanga, some miles further inland. The nature of the oil found there in these lower strata is in accordance with the view put forward. This oil had the relatively low specific gravity of 0·831, yielded 40% of a kerosene of specific gravity 0·809, which burnt well in a Hinks lamp, and which was of very low aromatic content. The crude was, moreover, rich in paraffin wax. This oil comes from a level below the coal-bearing strata. These facts suggest the possibility of the paraffin-rich and aromatic-poor oil having undergone some chemical interaction with the coal in its passage upwards, which resulted in a diminution of the wax content and increase in the aromatic and asphaltic constituents. It is difficult to understand in what way such a change could have come about. The facts, however, exist and need some such explanation. In the Miri fields, where coals are absent, the oil is low in aromatic and asphaltic content; the oils of Perlak, in Sumatra, where coals are absent, are lower in aromatic and asphaltic content than those of Moera Enim, in which field coals are present. The fact also that the difference in character with increase of depth is so very much less marked in the Tarakan field, where the geological conditions are much more favourable for easy migration, lends support to this idea.

Flotation of Cassiterite.—Patent No 28,999 of 1919 (159,025) granted to M. T. Taylor and J. W. Partington describes the process for concentration of tin ores by flotation as developed at East Pool mine, Cornwall. Herewith is given the specification.

The present invention is based upon the observation that sulphonated fatty or resin acids have a favourable effect in promoting the separation of certain metal compounds, for instance, the compounds of tin and tungsten such as the oxides of the metals referred to and scheelite occurring in ores. In accordance with the invention, products obtained by treating fatty or resin acids with sulphuric acid are employed. The fatty acids whose sulphonated derivatives are employed in accordance with the invention are the higher fatty acids such as are present in oils and fats, and the resin acids are ordinarily those derived from colophony. The fatty acids obtained for instance by treating soap or a solution of soap with a weak acid medium to effect the separation of the fatty acids, or soap itself may be treated with strong sulphuric acid, during which treatment it will be found that sulphur dioxide is liberated. The waxy product obtained, which is usually of a blackish or dark colour, separated from the aqueous layer formed in the treatment, and optionally also from any crystalline

matter separating from the aqueous layer, may be employed in the flotation process.

In the treatment of soap with strong sulphuric acid in the manner indicated, it would appear that derivatives as, for instance, sulphonated products or derivatives of certain fatty and/or resin acids contained in the soap are formed. The sulphonated fatty or resin acids may be employed in the form of a solution in, or otherwise in association with, agents which in themselves may act in the direction of facilitating the separation of the metallic values in consequence of their selective action for certain minerals or of their emulsifying or froth-forming properties. Thus the sulphonated fatty or resin acids may be dissolved in or employed in association with esters of fatty acids as, for instance, propyl, butyl, or amyl acetates, and/or with cyclic compounds containing nitrogen in the ring as, for instance, pyridine or like compounds, or commercial products containing these bodies, and the solution thus produced may be associated with phenolic bodies such as phenol itself or eucalyptus oil or other oily bodies hitherto employed in flotation processes.

The flotation of tin, tin oxide, wolfram, and scheelite can be effected by the employment of flotation agents in accordance with the invention, and it has been found by the inventor that by the employment of equal parts by weight of the fatty acids of palm oil and strong sulphuric acid in forming a sulphonated product, which is employed together with pyridine and amyl acetate in the manner above indicated, particularly good results may be obtained in the separation of these minerals from the gangue and other matters with which they are normally associated in the form of ores or concentrates.

The following particulars are given, by way of example, for the purpose of illustrating a suitable manner of carrying the invention into effect: Soap or the fatty acids set free by the treatment of soap with weak acids as, for instance, sulphuric acid of 10% strength, or by means of acetic acid, are treated with strong sulphuric acid of, for instance, 95% strength, and the product which floats on the aqueous layer is further treated with, for instance, pyridine or amyl acetate, or both pyridine and amyl acetate, after separation from or while in contact with said layer, so that the product is dissolved by the pyridine or amyl acetate, or forms compounds therewith. From what has been stated above it will be understood that instead of pyridine other cyclic compounds containing nitrogen in the ring may be employed, and that instead of amyl acetate other fatty acid esters may be used. The fatty acids of palm oil are treated with an equal weight of concentrated sulphuric acid with or without the aid of heat. Sulphur dioxide is evolved and the resulting product is usually dark in colour. When the reaction has ceased, the product floating upon the aqueous layer is separated either by decantation or by allowing the reaction mixture to cool and separating the solid reaction product. The reaction product, which is more or less solid at ordinary temperatures, is then masticated or kneaded or boiled with water to remove the free mineral acid with which it may be associated.

The product thus obtained may be added in the solid state to the material as, for instance, by introducing it into the flotation apparatus in which it will be converted into an emulsion with the water, or it may be previously emulsified with water or dissolved in any suitable solvent as, for instance, pyridine or like nitrogen-containing cyclic compounds, or propyl, butyl, or amyl acetate, or the corresponding alcohols, and the emulsion or solution may be then added to the material to be subjected to the flotation treatment. The ore or mineral-bearing material is crushed to pulp of a suitable degree of fineness either by wet or dry crushing, and is then conveyed to a flotation apparatus where the said pulp is agitated with water, and in the course of this agitation a small portion of the flotation agent according to the invention is added to it. This flotation agent attaches itself preferentially to the mineral particles in the ore and leaves the gangue or waste substantially unaffected. Air in minute sub-division is introduced into the aqueous pulp and attaches itself to the reagent-coated mineral particles, thus carrying them to the surface in the form of a froth or scum, which is collected, and the mineral separated therefrom by settling or other suitable means.

Arizona Copper Company's Metallurgy.—In the *Engineering and Mining Journal* for February 5, J. O. Ambler writes on the method of saving gold and silver at the Arizona Copper Company's smelting plant. The average gold content of the blister copper per ton is 3 dwt., and the silver content averages 5 oz. per ton. This precious metal could not be recovered profitably by electrolytic refining, so experiments were made in the converter with the object of reproducing the old Welsh method of collecting gold and silver in the bottoms. The results were sufficiently encouraging, and the author gives a description of the practice eventually adopted. A charge consisting of about fifty tons of matte and the necessary silicious ore and cleanings is blown in 12 ft. Great Falls-type converters to the white-metal stage as usual. The white metal is then blown until part of it is converted into copper, this blowing time being dependent on the amount of white metal in the charge, the percentage of enriched product desired, and the other operating factors. The converter is then turned down, and the overlying white metal is poured off into a ladle. The copper remaining in the converter, which still contains a small amount of white metal and is enriched in gold and silver, is finished and poured as usual, this operation taking from three to five minutes, depending on how clean a separation has been made. The white metal which was poured off into the ladle is then poured into the same converter and finished, the copper produced being impoverished in gold and silver. The principal difficulties encountered in operation are to control the percentage of copper produced as "enriched," and to obtain a clean separation when skimming the white metal from the enriched product. As a result of experience, the operators at the plant can now estimate the percentage of enriched product with a fair degree of accuracy, but the results obtained are still entirely empirical. With a charge containing about fourteen tons of copper, the blowing time to produce 55% of enriched product from the white-metal stage averages from fifty to fifty-five minutes under the conditions prevailing in this plant, but this varies with the size of the charge, cleanness of the skim, temperature of the charge, amount of cold scrap fed, temperature of the blast, and other conditions, and is still largely a matter of good judgment based on experience. The foremen in charge have developed a scheme for separating the copper and white metal, by observation of the appearance of the molten stream on a rabble blade, which is entirely satisfactory.

SHORT NOTICES.

Subsidences and their Prevention.—At the March meeting of the South Wales Institute of Engineers, R. C. Morgan read a paper on the causes of subsidences in coal mines and the best safeguards for their prevention.

Compressed Air in Mines.—The *Colliery Guardian* for March 4 contains a report of a discussion at Wigan Mining College on the relative suitabilities of compressed-air power and electric power in mines.

Flotation of Coal.—A paper by E. Bury, W. Broadbridge, and A. Hutchinson on the application of froth flotation to the purification of coal is published in the Transactions of the Institution of Mining Engineers.

Monel Metal.—In *Chemical and Metallurgical Engineering* for February 16, Paul D. Merica writes on the physical characteristics of monel metal, the alloy of copper and nickel.

Nickel Alloys.—In *Chemical and Metallurgical Engineering* for March 2, Paul D. Merica, of the research department of the International Nickel Co., writes on nickel steels and iron alloys high in nickel.

Chloridizing-Roasting of Copper Ores.—In the *Engineering and Mining Journal* of March 5, N. Ostman describes the Ramen-Beskow furnaces used in extracting copper from burnt pyrites by roasting with salt and subsequent leaching. These furnaces and the chemical considerations connected therewith were described in the MAGAZINE for December, 1918.

Electric Iron Smelting.—In *Chemical and Metallurgical Engineering* for March 9, Gerard de Geer writes on electric smelting of pig iron at Domnarfvet, Sweden.

Cobalt Brasses. — *Chemical and Metallurgical Engineering* for March 9 publishes a translation of a paper by Leon Guillet, which appeared in a recent issue of *Revue de Metallurgie*, on cobalt brasses.

Copper Assay.—In the *Engineering and Mining Journal* for March 19, G. J. Hough describes a modification of the Fleitmann method of copper assay.

Mount Quamby, Queensland.—The *Queensland Government Mining Journal* for January contains a paper by Lionel C. Ball on the Mount Quamby gold deposits between Cloncurry and Mount Cuthbert.

Cobalt in Queensland.—The *Queensland Government Mining Journal* for January publishes a paper by J. H. Reid on the deposit of cobalt near Selwyn, in the Cloncurry district. Note of this deposit was made in the MAGAZINE for November last.

Gold and Platinum in Chile.—In the *Engineering and Mining Journal* for March 19, F. Mella describes alluvial deposits containing gold and platinum on the island of Chiloe off the coast of southern Chile.

Spanish Pyrites.—In the *Mining and Scientific Press* for January 22, Courtenay De Kalb writes on the pyrites industry of South Spain. In the issue of February 5 he describes the methods of extracting the copper.

Pyrites in Coal.—At the meeting of the Manchester Geological and Mining Society held on March 8, James Lomax read a paper on the various forms of pyrites in coal, their probable origin, and their effects on being exposed to atmospheric influences.

Nevada Consolidated.—In the *Mining and Scientific Press* for March 5, A. B. Parsons commences an article giving a historical account of the Nevada Consolidated Copper Company.

Gold Mining in Nicaragua.—In the *Mining and Scientific Press* for March 12, Robert Hawxhurst, Jr., describes the Piz Piz gold-mining district, Nicaragua.

British Aluminium Water Power.—The *Engineer* for March 4 contains an illustrated article describing the new scheme for providing additional electric current for the British Aluminium Company's smelting works near Fort William, Scotland, by utilizing the waters of Lochs Trieg and Laggan and of adjoining rivers.

Borneo Petroleum.—In the *Engineering and Mining Journal* for March 5, W. H. Emmons and J. W. Gruner write on the Sanga Sanga oilfield in the Koetei district, Borneo.

Mexican Oil.—In the *Engineering and Mining Journal* for March 19, A. H. Redfield discusses the oil resources of the states on the isthmus in Mexico, Vera Cruz, Oaxaca, and Chiapas.

Conditions in China.—*Mining and Metallurgy* (New York) for March contains a paper by H. Foster Bain entitled: "Problems Fundamental to Mining Enterprise in the Far East."

RECENT PATENTS PUBLISHED.

☞ *A copy of the specification of any of the patents mentioned in this column can be obtained by sending 1s. to the Patent Office, Southampton Buildings, Chancery Lane, London, W C.2., with a note of the number and year of the patent.*

19,027 of 1919 (158,288). J. G. MACLEOD, London, and W. J. BROWNING, Rio Tinto. Obtaining sulphuretted hydrogen from sulphurous gases obtained by the roasting of sulphides, by passing these gases continuously through a carbonaceous zone maintained incandescent by its own combustion.

21,220 of 1919 (158,293). A. MATHESON, London. Method of producing soluble phosphate from alunite.

22,056 of 1919 (158,294). S. E. MUNOZ, Lorenzo Marquez, and S. SERUYA, Johannesburg. Cushioning devices for hand hammer-drills.

23,318 of 1919 (158,926). A. J. and H. D. EVANS, London. Improved method of recovering tin from tin-pot skimmings.

24,766 of 1919 (159,244). C. M. CONDER and G. T. TWYNAM, Camborne. Improved crusher of the roller and ring type.

25,056 of 1919 (158,937). W. GALLAGHER, Johannesburg. Instrument for surveying bore-holes.

26,470 of 1919 (134,536). MASUMI CHIKASHIGE and DENZO UNO, Kyoto, Japan. Extracting selenium and other metals from the slimes of electrolytic refining plant.

27,951 of 1919 (158,708). A. H. JONES, Tonopah, Nevada. Flotation machine.

28,355 of 1919 (158,992). A. A. KELLY and B. D. JONES, London. Method of preparing alkali pentaborates from boronatrocalcite or other boron minerals.

28,546 of 1919 (159,008). J. E. HURST, Mansfield, and E. B. BALL, Troon. Aluminium alloy suitable for internal combustion engines containing 0·5 to 6% of chromium.

28,763 of 1919 (159,280). W. B. BALLANTYNE, London. Method of introducing chromium or other refractory metal into steel.

28,832 of 1919 (159,285). E. EDSER, H. L. SULMAN, and F. B. JONES, London. Improvements in process for floating coal, based on W. Russell's process described in Patent No. 122,454.

29,031 of 1919 (158,740). W. P. HESKETT, Wanganui, New Zealand. Method of producing fine metallic powders.

29,283 of 1919 (159,314). W. W. RICHARDSON, London. Improvements in the inventor's revolving classifier and concentrator.

29,303 of 1919 (147,530). NEW JERSEY ZINC Co., New York. Improvements in the Wetherill process for making zinc, lead, and other oxides.

29,359 of 1919 (159,318). R. H. BICKNELL, London. Tunnelling machine.

30,340 of 1919 (159,342). D. WHITAKER, Leicester. Tunnelling machine.

30,951 of 1919 (159,071). J. J. COLLINS, Winsford, Cheshire. Method of extracting tin from ores by treatment with dry chlorine gas. This process was described in the MAGAZINE for November, 1920.

31,814 of 1919 (159,380). R. STOREN, Kongsberg, and R. JOHANSON, Odda, Norway. In magnetic

separation, a method of rendering pyrrhotite permanently non magnetic so that weakly magnetic iron oxides can be separated from it.

1,712 of 1920 (159,086). S. E. SIEURIN, Hoganas, Sweden. Method of producing alumina from aluminium chloride formed by treating aluminium ores in hydrochloric acid.

5,510 of 1920 (154,167). F. COURTOY, Brussels. Coal washer

6,092 of 1920 (139,523). SIEMENS-SCHUCKERTWERKE, Berlin. Rotary rock-drill.

6,912 of 1920 (140,069). SCHIELE & BRUCKSALER, Hornberg, Baden. Increasing the resistance of aluminium to acid and alkaline liquids.

8,213 of 1920 (159,102). GENERAL ELECTRIC Co., Schenectady, New York. Producing a coating of chromium-iron alloy on surfaces of iron and steel.

11,326 of 1920 (142,129). J. CHOPPINET, G. GILLON, and V. DEFAYS, Brussels. An apparatus for determining the deviations of bore-holes, comprising a rocking beam suspended above a disc having uniform rotary motion, which moves laterally in accordance with the deviations of the bore-hole, the rocking beam carrying devices arranged in the apices of a regular polygon that is concentric to the rocking beam, said devices being arranged to come into contact with a radius of the rotating disc at intervals of time varying with the relative positions of the disc and the rocking beam, and the recording of which allows of determining the distances between the centre of the disc and the axis of the rocking beam, that is to say, the displacement of the disc and consequently the deviations of the bore-hole and the horizontal direction of said deviations.

12,941 of 1920 (143,218). WENDEL & CIE, Paris. Blasting cartridges using liquid air.

12,959 of 1920 (152,300). FULLER-LEHIGH CO., and A. G. KINYON, Fullerton, Pennsylvania. To assist the conveying of coal dust by pressure, the introduction of small amounts of air into the bottom of the conduits, thus making the dust fluent.

NEW BOOKS, PAMPHLETS, Etc.

☛ Copies of the books, etc., mentioned below can be obtained through the Technical Bookshop of *The Mining Magazine*, 724, Salisbury House, London Wall, E.C.2.

American Petroleum Register. Price $10·00. New York: *Oil Trade Journal*, 120, Broadway.

The Recovery of Nitrate from Chilean Caliche. By A. W. ALLEN. Cloth, octavo, 50 pages. Price 6s. net. The author first describes the standard Shanks process for extracting nitrate, and then proceeds to deal with his own process, for which patents are pending.

Year-Book of the Scientific and Learned Societies. Cloth, octavo, 360 pages. London: Charles Griffin & Co., Ltd. This is the 37th annual issue of a most useful handbook giving details of the various scientific and technical societies, with records of the papers and transactions during the year.

Phosphate in Canada. By HUGH S. SPENCE. Published by the Canadian Department of Mines.

Geology of the Plateau Tin Fields. By J. D. FALCONER. Published by the Geological Survey of Nigeria.

Lead Ores. By T. C. F. HALL. Paper covers, 135 pages. Price 6s. net. Published for the Imperial Institute by John Murray.

Handbook of Metallurgy, Vol. 1. By CARL SCHNABEL, translated by HENRY LOUIS. Cloth, octavo, 1,180 pages, illustrated. Price 40s net. London: Macmillan & Co., Ltd. This is the third edition of this well known book. A detailed review will follow later.

COMPANY REPORTS

East Pool & Agar.—As reported last month, this tin-wolfram-arsenic mine near Camborne, was shut down in February owing to the low price of metals and the high cost of wages and coal, though pumping is being continued in order that the property may be kept in good order. The report for the year 1920 shows that 74,433 tons of ore was raised and sent to the mill, 47,524 tons coming from the famous Rogers lode. The yields were 874 tons of tin concentrate, 46·8 tons of wolfram, and 500 tons of crude arsenic. The yield of tin concentrate per ton was 26·32 lb., and the calculated recovery in chemical assay was 68·8%. The amounts realized on the sale of the several products were £152,015, £1,024, and £22,728 respectively, making a total of £175,767, or 47s. 3d. per ton of ore milled. Other revenue brought the receipts to £180,310. The total expenses were £208,318, or 55s. 11d. per ton, so that there was a net loss for the year of £28,007. During the year, a large amount of development was done, with gratifying results, which are described in the extracts from Bewick, Moreing & Co.'s report given herewith.

On the 190-fathom level, the main east drive, on the Rogers Lode, was continued beyond the elvan, and for the 248 ft. driven disclosed ore averaging 48·5 lb. black tin and wolfram per ton over a width of 6 ft. A winze, at 520 ft. east, was started from the above drive and sunk 24 ft. in ore averaging 34 lb. black tin and wolfram per ton for a width of 5 ft. A rise, at 636 ft. east, was also started from the main drive, and extended 83 ft. in ore averaging 81 lb. black tin and wolfram per ton for a width of 6 ft. On the 212 fathom level, the main west drive was advanced 161 ft., to a total of 948 ft., the ore disclosed averaging 34·5 lb. black tin and wolfram per ton for an exposed width of 6 ft. The main east drive was advanced 129 ft. through the elvan course, but has not yet reached the downward extension of the high-grade ore opened up beyond the elvan at the 190-fathom level. On the 240-fathom level, the main west drive was advanced 119 ft. to a total distance of 506 ft., the ore disclosed averaging 34 lb. black tin and wolfram per ton for an exposed width of 6 ft. An east branch drive (826 ft. north, 150 ft. west), off the north side of the main east drive, was started and advanced 58 ft. in ore averaging 27·5 lb. black tin and wolfram per ton over an exposed width of 5·5 ft. On the 252-fathom level, a main north cross-cut, for opening up the Rogers Lode at this level, was started and extended 735 ft. from East Pool shaft and intersected the following: At 80 ft. north, the Red Lode averaging 70 lb. black tin per ton for a width of 5 ft.; at 336 ft. north, Branwell's Lode averaging 45 lb. black tin per ton for a width of 5 ft. (Where met in higher levels these lodes usually have been unprofitable, but the values above stated indicate that probably an improvement is taking place in depth as has been experienced in adjoining mines); at 430 ft. north, a lode averaging 37 lb. black tin per ton for a width of 8 ft.; at 537 ft. north, a lode averaging 82 lb. black tin per ton for a width of 5 ft.

On the 255-fathom level, the Tolgus tunnel, driven east from the most easterly workings in the Agar section, encountered what is believed to be the Great Lode at a distance of 860 ft., and for the 11 ft. driven on the lode the ore averaged 84 lb. black tin and wolfram per ton over an exposed width of 8½ ft. The full width of the lode was subsequently exposed by a south cross-cut from the tunnel, and averaged 158 lb. black tin and wolfram per ton for 13 ft. wide. The Great Lode has been extensively mined in both East Pool and Agar sections for a length of 2,700 ft., and for many years was the most productive lode worked on the property.

The distance from the most easterly workings in the old part of the mine to the eastern boundary is 2,000 ft., and the values disclosed in the tunnel give reason to believe that the Great Lode in this section also will produce large tonnages of profitable ore.

Tehidy Minerals.—This company was formed in February, 1919, to acquire the mineral rights of the Tehidy (or Basset) estate, near Camborne, other than the mining rights belonging to the Dolcoath and East Pool companies; in the August following the mineral rights of the Lanhydrock (or Clifden) estate were acquired. Particulars of the Tehidy estate were given in the MAGAZINE for July, 1919, and of the Lanhydrock estate in April, 1920, in each case accompanied by an exploratory map. The report now issued covers the period from the registration of the company to the end of 1920. The delay in issuing the report is due to difficulties in connection with the transfer of the Tehidy rights. The accounts show an income of £12,892 from Tehidy dues and rents, and £14,588 from Lanhydrock dues and rents. The administration expenses were £10,744, and income tax absorbed £8,429. The net balance of profit was £9,621, which was carried forward. The company has taken a substantial interest in the Cornish Kaolin, Ltd., whose works are situated at Bodmin Road, and has sold to them a portion of its clay areas. Cornish Kaolin's pipe-line and railway sidings afford an outlet for the working of the company's extensive china-clay deposits on Bodmin Moor and form the foundation from which this development will proceed. The company has purchased, since the end of 1920, from H. D. Pochin & Co., Ltd., their well-known works situated at Burngullow, and the Halviggan clay pits which are on the company's property, and which are connected with the Burngullow works by a pipe-line. The acquisition gives an outlet to sidings on the railway for working the company's clay deposits at Halviggan and district. Both these works are situated on the Great Western main line and are near the china-clay port of Fowey.

South Crofty.—As recorded last month, the mine and mill of this tin-mining company at Camborne were closed on February 12 owing to the high cost of wages and materials and the low price of tin. The report now issued covers the year 1920. During this period 69,960 tons of ore was raised and treated, from which were extracted 589 tons of tin concentrate, 38 tons of wolfram, and 645 tons of arsenic. The value of these products was £145,913, or 41s. 8d. per ton of ore milled. The profit and loss account shows total credits of £153,420, and a net profit of £3,056. The costs at the mine were 35s. 8d. per ton. The yields per ton were 18·8 lb. tin concentrate, 1·22 lb. wolfram, and 20·68 lb. arsenic. As regards development, the results have continued to be satisfactory. In the deepest levels at 260 fm. and 290 fm. in Robinson's section, comparatively high assay-values have been obtained over portions of the ground, while two new lodes of some promise have been discovered. Now that all the mines in the district are closed, the question of individual or collective pumping has arisen. At South Crofty there is a likelihood of a considerable increase in the amount of water coming in if complete stoppage or certain alterations in methods were adopted at adjacent mines. Hence the necessity for collective action.

Robinson Gold.—This company was formed in 1887 to work an outcrop mine in the central Rand, and for many years the returns were large and the mine was the greatest gold mine of the world. J. B. Robinson was the first chairman, but the control soon passed to the Ecksteins and later to the Rand Mines group. The mine is near exhaustion, and for some years operations have subsisted on the treatment of low-grade ore. The report for the year 1920 shows that 475,400 tons, averaging 4·7 dwt. per ton, was raised and sent to the mil without sorting. The yield by amalgamation was 63,397 oz., and by cyaniding 40,229 oz., making a total of 103,626 oz., or 4·36 dwt. per ton. The revenue was £573,570, of which £143,103 accrued from the gold premium. The revenue per ton was 24s. 2d., of which 6s. 1d. was premium. The working cost was £487,367, or 20s. 6d. per ton, leaving a working profit of £86,202, or 3s. 8d. per ton. It is clear, therefore, that the mine exists on the gold premium. The shareholders received £82,500, the dividend being at the rate of 3%. The reserve in the Main Reef Leader and South Reef is estimated at 115,200 tons, not valued. There is a large amount of ore remaining in the Main Reef, but only small portions of it are of sufficiently high grade to warrant extraction. Ore is still being extracted from the old workings and by the reclamation of pillars, but the resources in this direction cannot be estimated. Thus the remaining life of the mine is difficult to forecast.

Rose Deep.—This company was formed in 1894 to acquire claims on the dip of the reef below New Primrose in the near east Rand. In 1909 the adjoining Glen Deep was absorbed. The control is with Rand Mines, Ltd. The report for the year 1920 shows that 713,431 tons of ore was raised, and, after the removal of 9% as waste, 643,600 tons of ore, averaging 5·4 dwt. per ton, was sent to the mill. The yield of gold by amalgamation was 101,142 oz., and by cyaniding 62,644 oz., making a total of 163,786 oz., or 5·09 dwt. per ton milled. The revenue from the sale of gold was £900,917, or 28s. per ton milled. The working cost was £679,898, or 21s. 2d. per ton, leaving a working profit of £221,018, or 6s. 10d. per ton. The proportion of the revenue accruing from the premium on gold is not specifically given, but it is stated that but for this premium the margin between revenue and expenditure would have been extremely small. The shareholders received £192,500, the dividend being at the rate of 27½%. The development work has continued to give satisfactory results, and the reserve is estimated at 3,060,040 tons averaging 5·1 dwt. per ton, as compared with 3,031,280 tons averaging 5·2 dwt. the year before.

Consolidated Diamond Mines of South-West Africa.—This company was formed in February, 1920, by the Consolidated Mines Selection group, to acquire the properties of the principal German diamond-mining companies operating in South-West Africa. The first annual report, now issued, covers the period from October 1, 1919, to December 31, 1920. Of the German companies, the Pomona, Koloniale, and Deutsche were the biggest producers. Operations were continued by the German companies until March, 1920, after which date the present company took control and rearranged the work accordingly. The accounts show an estimated profit of £128,365 for the period from October 1, 1919, to February 16, 1920. From February 16 to the end of the year the sales of diamonds brought an income of £1,455,143, and on December 31 the stock of 346,675 carats was valued at £416,208, being the cost of production. The mining expenses were £501,997, administration expenses £27,720, allowance for depreciation £123,996, interest on debentures £131,821, allocation to sinking fund for redemption of debentures £138,742, and payment to the Government £404,237. The balance of profit for February 16 to December 31 was £249,973. Owing to the uncertainty of the diamond market no dividend has been declared. The engineer gives the figures for the output of diamonds during 1920 as 545,027 carats, ob-

tained by treating 1,106,729 cubic metres of ground.

Associated Northern Blocks. This company was formed in 1899, as a subsidiary of the Associated Gold Mines of West Australia, to work the Iron Duke and other properties at Kalgoorlie, West Australia. For many years satisfactory profits were earned. Later the property was let on tribute. In 1910 the Victorious mine at Ora Banda was acquired. This property has also been let to tributers. The report for the year ended September 30 last shows that 17,316 tons was raised by the tributers at the Victorious, which yielded gold worth £32,757 at par, and that 14,981 tons was raised by tributors at the Iron Duke, yielding gold worth £45,622 at par. After the receipt of the premium on gold, £11,717, the profit accruing to the company was £13,756, out of which £3,419 was written off for development and depreciation. The balance brought forward from the previous year was £21,997, so that the disposable balance of profit at the end of 1920 was £32,334. Out of this, £17,500 was distributed on March 31, 1920, the dividend being at the rate of 1s. per share, tax paid. In 1910 the company purchased the El Refugio mine in Zacatecas, Mexico. This was subsequently let on lease, and the report now states that the lessee has commenced the erection of a milling plant.

Globe & Phœnix.—The report of this celebrated gold-mining company operating in Rhodesia, covering the year 1920, gives no details of the ore mined and treated. The profit and loss account shows an income of £379,880 from the sale of bullion at par value, to which is added £153,457 received as premium on the sale of the gold. The profit for the year was £344,042, of which £78,945 was paid out for income tax and corporation tax, £100,000 was placed to development reserve, while £240,000 was distributed as dividend, being at the rate of 120%. The ore reserve is calculated at 93,852 tons averaging 31 dwt. per ton. The last previous report as regards ore reserves was published in October, 1919, when the figures were 143,333 tons averaging 30 dwt. At the end of 1918, the figures were 159,913 tons averaging 29·4 dwt., and at the end of 1917, 184,053 tons averaging 28·9 dwt. It is clear that mining operations have depended on the ore reserve for some time. The present report on development work received from D. P. McDonald indicates improvements in the results at various points, but he confesses that more good luck is desirable.

Jos Tin Area (Nigeria).—This company was formed in 1910 to work a number of tin-mining leases in Nigeria. The report for the year ended July 31, 1920, shows that 143 tons of tin concentrate was won, as compared with 233 tons the year before, the fall being mainly due to shortage of labour. For the six months ended January 31, 1921, the output was 131½ tons. Owing to the present low price of tin, the rate of output has been reduced and the staff has been cut down considerably. The profit for the year under review was £1,214, which was carried forward. In writing of this company last October, we referred to a report for the year ended July 31; this report was for the year ended July 31, 1919, not July 31, 1920.

Hollinger Consolidated Gold Mines.—The tenth annual report of the leading gold-mining company operating at Porcupine, Ontario, for the year 1920, shows that 650,205 tons of ore was sent to the mill, averaging \$9·93 per ton. The gold produced was valued at \$6,219,664, or \$9·56 per ton. The receipts during the year including the premium on gold were \$6,939,628, and \$222,982 was received as dividends and interest. The working cost was \$3,144,328, or \$4·83 per ton of ore treated. Taxes absorbed \$225,940, \$445,985 was written off for depreciation of plant, \$408,250 was written off development account, and \$260,872 was written off investments. The net profit was \$2,675,274, of which \$2,214,000 was distributed as dividends. The ore reserve was estimated at 3,294,005 tons, averaging 11 dwt. per ton. Two years earlier the reserve was estimated at 4,275,570 tons averaging \$9·00 per ton. In the later estimate all ore lower than \$6·00 has been eliminated. Virtually the whole of the calculated reserve is above the 800 ft. level. The lodes have been proved below this, and down to 1,350 ft., but no estimate of their contents has yet been made.

Mexico Mines of El Oro.—This company has worked a gold mine at El Oro, Mexico, since 1904. As the mine is fully developed, a subsidiary exploration company was formed a year or two ago and the control of other properties has been acquired, but owing to adverse conditions in metals the new ventures are in abeyance at present. The report for the year ended June 30 last shows that 138,710 tons of ore was milled, averaging \$11·36 in gold and 8·39 oz. silver per ton. The yield of gold was \$1,435,381 and of silver 972,934 oz., being recoveries of 91% and 83·5% respectively. The accounts show an income of £533,808 from the sale of the gold and silver, and a net profit of £196,579, out of which £189,000 has been distributed as dividends, being at the rate of 90% tax paid. Developments continue to disclose ore, and during the past year blocks of ore higher in silver than gold have been found on the 3rd, 4th, and 9th levels. The reserve is estimated at 350,100 tons, averaging \$10·92 gold and 8·82 oz. silver per ton, a decrease of 29,100 tons in tonnage and \$0·68 in gold content, and an increase of 0·22 oz. silver, as compared with the figures a year before.

San Francisco Mines of Mexico.—This company was formed in 1913 to acquire silver-lead-zinc mines near Parral, Chihuahua, Mexico, previously worked by the San Francisco del Oro company. The report for the year ended September 30 last shows that the concentrator, enlarged to a daily capacity of 100 tons toward the end of 1919, was at work as continuously as Mexican conditions allowed. During the period under review 25,087 tons of ore was treated in the concentrator, averaging 9·4% lead, 20·2% zinc, 0·8% copper, 1·28 dwt. gold, and 20 oz. silver. The yield of lead concentrate was 5,901 tons, averaging 30·4% lead, 21·4% zinc, 3 dwt. gold, and 41 oz. silver. The recovery of the lead was 77% and of silver 47%. The output of shipping ore was 8,064 tons, averaging 8·76% lead, 18·45% zinc, 1·75 dwt. gold, and 33 oz. silver, together with 644 tons of oxidized ore averaging 6·56% lead, 1½ dwt. gold, and 19 oz. silver. The total received for the concentrate and shipping ores was 1,657,074 pesos. The profit made by the company was £33,149, as compared with a loss of £40,900 the year before. Plans are in hand for the extension of the concentrator to a capacity of 250 tons per day. The finances of the company are to be rearranged so that payment of interest on debentures may be suspended for three years, and funds arising from profits thus released for the requirements of the mine.

British Aluminium.—This company operates four hydro-electric aluminium smelting works, two of them being in Scotland, and two in Norway, and it also owns rolling mills in Stafford and Lancashire. The report for the year 1920 shows a net profit of £137,611, of which £118,077 has been distributed as dividend, being 6% on the preference and 10% on the ordinary shares. The company does not give particulars of the output of aluminium. The works have been considerably extended during the year, and were fully employed. Since the close of the year, however, the fall in consumption has been such that it has been necessary to curtail seriously the output at the various works.

The Mining Magazine

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Brakpan Mines; Camp Bird; Chendai Consolidated; City Deep; Consolidated Langlaagte Mines; Crown Mines; Durban Roodepoort Deep; Geduld Proprietary Mines; Geldenhuis Deep; Gopeng Consolidated; Government Gold Mining Areas (Modderfontein); Knight Central; Langlaagte Estates & Gold; Mason & Barry; Mexican Corporation; Meyer & Charlton; Modderfontein B; Modderfontein Deep Levels; New Kleinfontein; Ooregum Gold; Pengkalen; Plymouth Consolidated Gold Mines; Rambutan; Randfontein Central; Santa Gertrudis; Sons of Gwalia; Springs Mines; Tekka-Taiping; Tharsis Sulphur & Copper; Van Ryn Deep; Village Deep; Witwatersrand Deep; Witwatersrand Gold.

EDITORIAL

THE new village built by the Anglo-Persian Oil Company at Skewen, near Swansea, has been christened "Llandarcy," in memory of the late Mr. W. K. D'Arcy. This village is intended for the accommodation of employees at the company's great oil-refinery.

IT is often complained that, though the American economic geologists have contributed in no small degree to the elucidation of many problems connected with ore deposits, their knowledge of the world outside their own country is restricted. An example of this contention is provided by the fact that the title page of *Economic Geology* mentions as one of the associate editors of that magazine Dr. E. T. Mellor, of "Johannesville."

WE take pleasure in announcing that a series of special lectures on the zinc industry are to be given at the Sir John Cass Technical Institute, Jewry Street, Aldgate, by Messrs. J. C. Moulden and E. A. Smith. Mr. Moulden will give two lectures on "Modern Developments in the Zinc Industry," on May 25 and June 1, and Mr. Smith will deliver three on "Industrial Applications of Zinc," on June 8, 15, and 22. The lectures will each last for an hour, from 5.30 to 6.30 p.m., and the entrance fee for the course is 10s. 0d. The Institute is to be congratulated on having secured, during the last few years, the services of many eminent authorities willing to help the cause of education by giving freely from their store of experience. The Institute is doing excellent work in providing facilities for evening study, and these facilities deserve to be more widely known in mining and metallurgical circles.

ONE of the outward and visible signs of the new spirit in India is the publication of the *Journal of Indian Industries and Labour*, a quarterly magazine issued under the auspices of the Indian Government. The object of this magazine is to disseminate trade and technical information between the various provinces of India, which under the new regime are largely independent of each other in policy and administration. In addition, it is intended to issue separate Bulletins on special subjects. The first number contains articles on the possibilities of industrial development in the Central Provinces and Berar, welfare work in Bombay cotton mills, researches in tanning, the gilt wire and tinsel industry at Burhanpur, trade disputes in Bengal, industrial education in Madras Presidency, and the commercial aspects of bauxite. The last named is written by Dr. J. Coggin Brown, a member of the Indian Geological Survey who has, during the last year or so, done excellent work in London in bringing Indian mineral resources to the notice of the commercial community. Sir Thomas Holland supplies a foreword to this first number, recounting the circumstances under which the *Journal* has been founded. We take this opportunity of recording our appreciation of the services rendered by Sir Thomas and his associates in piloting India through a difficult transitional period.

THE board of directors of the Burma Corporation have made arrangements to purchase the control of a number of English lead smelters. This control was secured recently through the instrumentality of Mr. R. Tilden Smith, who formed a company called the Associated Lead Manufacturers, Ltd., for the purpose. Mr. Tilden Smith, it will be remembered, has a very large interest in the Burma Corporation. The lead firms controlled by the Associated company are: H. J. Enthoven & Sons; Walkers, Parker, & Co.; Locke Lancaster & W. W. & R. Johnson & Sons; Foster, Blackett, & Wilson; and Alex. Fergusson & Co. This list includes all the chief English lead firms except Cooksons and Locke, Blackett & Co. The object of the Burma Corporation in acquiring the control is to provide an outlet for its lead concentrates and the marketing of products such as pig, sheet, and pipe lead and the various lead pigments. The policy is to smelt some of the concentrates locally and to dispose of the products in the East; and to ship the remainder to England for treatment by the firms named. The purchase price of the control is £400,000 in Burma Corporation debentures and £100,000 in cash, the latter being devoted to the purchase of Associated shares at par. It is believed that this policy will be cheaper and less disturbing to the lead trade than an enlargement of the Corporation's smelter and treatment works, while a firm of accountants show, by a ten years' record of the financial results obtained by the individual lead firms, that the investment in the shares of the Associated company should be lucrative. For some reason, which we shall not attempt to explain, this proposal was placed before an in-

formal meeting of shareholders without any indication of its nature having been given in the convening circular. Moreover, the representatives of the press were rigidly excluded. The attending shareholders were taken by surprise, and were further mystified by Mr. F. A. Govett's speech, in which he began by stating his objections to the scheme and ending by recommending shareholders to adopt it. During subsequent days Sir Trevredyn Wynne, the chairman, received many protests and deputations, finally promising to provide further information before completing the deal.

IN his paper on ore deposits of igneous origin read last month before the Cornish Institute of Engineers, Dr. R. H. Rastall drew attention to the question of searching for platinum in the serpentines of the Lizard district. Recent publications by Du Parc and Orueta have provided definite proof that the original home of the platinum group of metals in the Ural Mountains and in Spain is in the serpentinized ultrabasic rocks, and the alluvial platinum of Colombia is associated with boulders of serpentine. The possibility of platinum being found at the Lizard once more arises. Here there are large areas of serpentine, but no recorded assay shows any platinum content. The amount of platinum in the rocks is so small that failure to find it is not to be wondered at. Dr. Rastall suggests that a systematic search for alluvial deposits that have undergone natural concentration should be made, to be followed by extensive panning tests and assays. There are not many streams draining the Lizard serpentines, but it would be worth while to test the bedrock of such as there are.

IN another part of this issue we reprint the report of a committee of the Geological and Mineralogical Societies on the standardization of British petrographic nomenclature. Most geologists and mining engineers will accept the recommendations, though perhaps some will query the wisdom of abandoning the term "diabase." We understand, however, that its disuse was advised owing to its ambiguity. In early days the word was applied to somewhat decomposed basalts of Pre-Tertiary age, and in this sense the word was used largely in Germany. Later, Harker used it to denote basic intrusives of hypabyssal type, but afterward he replaced it by "dolerite." At the present time, when used by most of the scientific petrologists, it implies the idea of more or less decomposition, and thus a "diabase" may often be a "rotten dolerite." On the whole, therefore, the committee advised the retention of "dolerite" and the disuse of "diabase." There is one point in connection with the report that is distinctly comforting: no new terms are recommended. Perhaps in the not distant future it will be possible for the committee to get into contact with American petrographers. Attempts in this direction have proved fruitless hitherto, but as it is obviously desirable that there should not be two nomenclatures, one English and the other American, perseverance in this matter is essential.

Gold Stealing.

A little over two years ago we referred in these pages to the public scandal of gold stealing, which continuously takes place at the Kalgoorlie mines. It is an undoubted fact, and well known to the managers and metallurgists, that these mines have been losing at least £100,000 of gold annually owing to this pilfering of rich ore and crude gold. It is not necessary here to recapitulate the case of the mine-owners, or to show how the Government of West Australia has steadily refused to adopt the recommendations of the Commission on Gold Stealing appointed over fourteen years ago, and has objected to taking any strenuous action calculated to abate the nuisance. Our article in 1918 was written with the avowed object of stirring the Government, and of assisting the West Australian Chamber of Mines and the mine-owners in their campaign of self-protection. But still nothing is done, and the malpractices flourish as ever. The goldfields police, on the other hand, continue to act as alertly as the law allows them, and they have been successful in scotching two offenders. The first case occurred toward the end of 1919, when a man operating at the sand-treatment plant on Burbank's Birthday Gift mine was convicted of buying stolen gold and rich ore. This man had been suspected for some time of conducting a shady business of this sort, for the output of gold from the plant was obviously much in excess of any possible gold content of the material treated; but it took the police a long time to obtain evidence of a character that would satisfy the local courts. If there had been a law permitting the police to sample and assay the material fed to the plant there would be little difficulty in detecting frauds of this character. It is one of the contentions of the mine-owners that all treatment plants of this description should be open to official inspection at any time. Undoubtedly such a condition would act powerfully in suppressing bogus custom plants.

Another of the rare instances of conviction occurred in October last, when an employee of the Golden Horse-Shoe company was caught in the act of stealing 2½ lb. of gold slime. On being searched, his clothing was found to contain a number of unusual pockets evidently specially designed for receiving small and large amounts of purloined material. At his home were discovered a number of bags which bore the appearance of having contained gold slime. This man had been in the service of the Golden Horse-Shoe for ten years, and had previously been employed at the Ivanhoe for fourteen years. During the whole of that period his character had always been apparently above suspicion, yet the circumstances under which he was detected pointed to a systematic and carefully designed plan of campaign. It might be supposed that here was the opportunity for an exemplary punishment that would act repressively. But no! the magistrate referred feelingly to the fact that the culprit had a wife and children, and let him off with two months' imprisonment.

These thefts, as we have said, have been going on throughout the Kalgoorlie goldfield ever since the deposits were first exploited. The ownership of the mines is largely in the hands of English investors. In many quarters, not only in Australia, but elsewhere, there is a popular prejudice against investors, who it is ignorantly alleged neither put the gold into the rocks nor contributed toward getting it out. When the shareholders are over the seas this prejudice becomes more marked, and the means for combating it correspondingly diminishes. Apparently the authorities in West Australia are not sympathetic with English investors, or at any rate do not care to take any public step to show it. So the scandal remains, and presumably will never be checked. At the present time, however, when increased wages and costs are narrowing, if not annihilating, the margin of profit, it seems a pity that nothing can be done to stop this illegitimate reduction of income, even if only the interests of the wage earners are considered.

The Institution of Mining and Metallurgy.

At the thirtieth annual meeting of the Institution of Mining and Metallurgy, held on the 21st of last month, two important announcements were made with regard to the future of the society. In the first place, the home is to be moved from Finsbury Circus to City Road; and second, a close relationship has been arranged with the Institution of Mining Engineers, the society in Victoria Street.

As regards the approaching removal from Finsbury Circus, it will be remembered that this house and the land on which it stands was bought seven years ago, after the Institution had had ordinary offices, first at Broad Street House, and later in Salisbury House. At the time the house was purchased, the hope was that the home would be a permanent one, though the Council were not unaware of the fact that the property was old, and that it is situated in a position suitable for a modern office building. Finsbury Circus used to be composed almost entirely of houses such as that which the Institution occupies. Gradually these have disappeared, to be replaced by Salisbury House, London Wall Buildings, Broad Street Place, River Plate House, and No. 16, usually known as Shell-Mex. The remaining block of old property, together with similar property round the corner in West Street and Finsbury Pavement, has now been bought by the Eastern Telegraph Company, which is intending to erect a modern building similar to Electra House on the opposite corner of West Street and Finsbury Pavement, a house which it built about twenty years ago. In order to secure the Institution's premises and the land on which it stands, the company had to offer sufficiently attractive terms to induce the Council to agree to a removal. Here, however, a serious difficulty arose, for owing to the present congested state of office accommodation in the City no suitable alternative home could be obtained. Finally, in default of any better proposal, the Council agreed to accept the company's offer of Cleveland House, a building in City Road. Thus the Institution obtains the free occupation of this building for the remainder of the lease, 38 years, at a nominal ground rent, together with a sum of £20,000 in cash, and the expenses of removal and redecoration. The building is large and commodious, and the floor space is more than twice that at Finsbury Circus. The Council are, of course, justified in congratulating themselves on a satisfactory financial deal and on obtaining increased accommodation, but, on the other hand, they have to admit that the neighbourhood to which they are migrating is both inconvenient and unpleasant. The new home is nearly a mile from the old one, and is situated half way toward the Angel at Islington. It was originally built as the Vestry Hall of St. Luke's parish. Behind it is St. Luke's Workhouse, in Shepherdess Walk, and beside it is the Police Station, and also the Eagle, of which the jingle says: "Up and down the City Road, in and out the Eagle,

that's the way the money goes, Pop goes the weasel." It is also near Sir Thomas Lipton's cheap restaurant, known as the Alexandra Trust Dining Rooms; and not far away is St. Luke's Hospital for Lunatics. We do not exactly know why, but there seems to be something humorous in connection with what the Scotsman would call the amenities. There is no gainsaying the fact that the hearts of most members of the Institution fell into their boots when the news of the removal was broken to them. But it is no use blaming the Council, for they have equally suffered this anatomical rearrangement. Criticism is worse than useless, for it is not likely that anyone would have been able to discover a more acceptable solution of the difficulty. Perhaps it would be more heroic to view the position with a certain amount of pride, comparing the Institution to the People's Palace, Toynbee Hall, or the Oxford Settlement, shedding the light of culture and learning among the less-favoured classes of the population. In any case, it is more than probable that the new home will prove to be only a temporary makeshift.

The other matter to which reference was made at the meeting is the closer co-operation between the Institution of Mining and Metallurgy and the Institution of Mining Engineers. The latter society deals chiefly with the mining of coal and iron in this country, while the former is devoted to metals and minerals other than iron and coal. According to the view taken by each individual, the two societies may be supposed best entirely independent, or, owing to the complementary nature of the subjects, best amalgamated or at any rate drawn into closer co-operation. The Institution of Mining Engineers is in the nature of a federation of a number of local societies in this country, of which the North of England Institute has taken the most prominent part. It was originally hoped by the North of England Institute that the Institution of Mining and Metallurgy would join the federation, but the Institution considered that its aim and scope were so different from those of the provincial societies as to make such a step inadvisable. It may be said here that all these questions depend largely on the temperament of those who direct the fortunes of the societies. Thus it is probably a pity that the personal element prevented fusion or co-operation in those days. The matter was revived recently by certain engineers interested in both societies, of whom it is allowable to mention Sir John Cadman, and the Institution of Mining Engineers once more approached the Institution of Mining and Metallurgy, this time, however, in more deferential spirit. The course of negotiations need not be described here; suffice it to say that the two institutions have agreed to act together, without losing their identities, or interfering with their Royal Charters. The Institution of Mining Engineers is to move from Westminster and share the new home of the Institution of Mining and Metallurgy, and Mr. C. McDermid, the secretary of the Institution of Mining and Metallurgy, is to be also secretary of the Institution of Mining Engineers. Having thus effected this important preliminary step, both institutions will require time to get their breath, but it is obvious that before long a further settlement will have to be effected. The Institution of Mining Engineers is an unwieldy body, and has rather lost grip of affairs in recent years since the death of Mr. Walton Brown. Something ought to be done to abolish the local societies as such, and, if necessary, transform them into local sections of the mother society. Then it is desirable that the South Wales Institute of Engineers should be drawn into the circle. It is also to be recommended that the Institution of Petroleum Technologists should be associated in some way with the other two institutions. Afterwards the National Association of Colliery Managers and the Association of Mining Electrical Engineers should be approached, with a view to their ultimate extinction and the absorption of their chief activities. As for co-operation with societies in other parts of the Empire, this is foreshadowed in the report of the Council of the Institution of Mining and Metallurgy. There are other possible steps toward unification of interests connected with the mineral industries of the Empire, but the time for these has not yet arrived. In the meantime, it is the plain duty of all members of the Institution of Mining Engineers and the Institution of Mining and Metallurgy to see that the co-operation of the societies achieves the end desired, namely, the strengthening of the status of the mining engineer.

Rand Mining Results.

At this time of the year most of the companies operating on the Rand issue their annual reports. Our Mining Digest for this month and last contains abstracts giving the main features of the results obtained. These abstracts may be conveniently supplemented by a brief summary of the impressions gained by reading these reports. Two facts stand out prominently. In the first place, cost of production has continued to go up during 1920, and

many of the reports indicate the likelihood of further advances. On the other hand, some engineers are inclined to believe that a maximum has been reached, and that there are hopes for reductions before long. Judgment on this point is naturally influenced by the fact that there are enormous holdings of enemy shares hanging over the market, shares now in the hands of the British and Union Governments, who are trying their best to induce the financial houses to absorb them. Under such circumstances it is only business on the part of the financial houses to lay stress on the conditions most deterrent to a rise in share quotations. The other fact to which we refer is that two-thirds of the producers are existing largely if not entirely on the premium received for their gold.

In earlier years, when writing of Rand results, we made a practice of comparing the outputs and profits of the three great consolidations, Crown Mines, Randfontein Central, and East Rand Proprietary. The last occasion on which we reviewed the results of these companies' operations was in May, 1916, when the figures for 1915 were analysed and compared. In that year the outputs of gold were 763,063 oz., 680,697 oz., and 614,030 oz. respectively. For 1920 the figures were 672,738 oz., 409,669 oz., and 400,495 oz. During the interval, Crown Mines has been working steadily on its original development scheme, but the increased costs and comparatively low grade of the ore have prevented the full benefit being obtained from the excellent mining organization adopted. Randfontein Central has changed hands, and, under the auspices of the new controllers, the method of attacking the ore has been radically changed. The advantages to be obtained by this rearrangement of methods are now becoming obvious, and the large reserves of fair-grade ore point to increased outputs and profits. At East Rand Proprietary, the ore position has gradually become worse during the last few years, and profits have not been made; in fact, the very existence of the mine has been in constant jeopardy.

In 1915 the individual outputs of these three big consolidations were more than twice as great as that of any other mine on the Rand. In 1920, we find Crown Mines still the largest producer of gold with 672,738 oz., but the other two mines have been outstripped in the race by Government Areas with 600,154 oz., and New Modderfontein with 531,304 oz. Of other notable results in 1920, there may be mentioned City Deep with 351,363 oz., Modderfontein B with 312,218 oz., Van Ryn Deep with 306,614 oz., Modderfontein Deep with 267,873 oz., and Brakpan with 253,664 oz. Of the above-mentioned mines, all but East Rand Proprietary have excellent prospects. Other mines doing well are Meyer & Charlton, Geduld, and Springs, though the first-named is fully developed, and has no speculative prospects. Of new mines, Modderfontein East is producing and its prospects are fair. New State Areas and West Springs are in course of development, but work has not got much further than shaft-sinking. At Daggafontein, the results of development have not been very satisfactory so far, and operations are suspended for the present until further capital is forthcoming.

A number of mines have ceased production during the year, namely, Jupiter, Simmer Deep, Knights Deep, Village Main Reef, Princess Estate, City & Suburban, and New Heriot. Of producing mines not mentioned already, only the gold premium has made the financial position sound; in some cases the premium has made dividends possible, while in other cases the premium has barely kept the mines alive. Langlaagte Estate, Consolidated Main Reef, Kleinfontein, Robinson Deep, Rose Deep, and Village Deep appear to have plenty of life left in them, provided conditions are favourable, but Aurora, Consolidated Langlaagte, Durban Deep, Ferreira Deep, Geldenhuis Deep, Knight Central, Luipaard's Vlei, New Goch, New Primrose, New Unified, Nourse, Robinson, Roodepoort United, Simmer & Jack, Van Ryn, West Rand Consolidated, Witwatersrand (Knights), Witwatersrand Deep, and Wolhuter are either near the end of their reserves or are in too poor ground to pay dividends. But old mines die hard, and plenty of pluck is exhibited in keeping them going on the Rand.

The foregoing remarks may impart some idea as to the prospects of most of the mines on the Rand. There are many factors making for success or otherwise, but it must be remembered that comparative richness of the ore worked has now, as always, more influence on profits than large-scale working. The biggest profits on the Rand during 1920 have been made by the mines working rich ore, such as Meyer & Charlton, Van Ryn Deep, Modderfontein Deep, New Modderfontein, and Modderfontein B. To these and to Government Areas, City Deep and Crown Mines, Geduld, Brakpan, and Springs, large mines but of not quite the same grade, must be looked for profits during the next year or two, with hopes for Randfontein Central, New State Areas, and West Springs coming forward in the near future.

REVIEW OF MINING

Introduction.—The coal strike still continues and the manufacturing industries of the kingdom are at a standstill. The settlement can hardly come by any other way than a substantial reduction of wages, and the employees in all departments of trade are fully aware that they also must submit to reductions. It is a good augury that wages are being cut down drastically in the United States. In the meantime base-metal mining has shrunk to small dimensions, but a buoyant hope pervades the profession and the markets that things will be all right again soon.

Transvaal.—Précis of the reports of a large number of Rand gold-mining companies are given elsewhere in this issue, and also a general review of the results of output. There are one or two points of interest in these reports to which attention may be drawn. The deepest working on the Rand at present is in Village Deep, where the shaft is now 6,059 ft. vertically below outcrop. At City Deep, the mill was worked to full capacity for the first time, this having been made possible by the absorption of the underground staff, white and native, from the City & Suburban. In the Far East Rand, perhaps the most recent development of importance is in Geduld; here a large amount of high-grade ore has been discovered in the south-western part of the property adjoining New State Areas, and the prospects for finding further ore of the same quality are excellent.

The Union Government has held a statutory inquiry into the closing down of Daggafontein, when Mr. Carl Davis, the consulting engineer, gave a full account of the mining difficulties that had supervened. All sorts of suggestions have been made by outsiders for raising further working capital, including a proposal that the Government should lend some of its huge profits accruing from Government Areas, and another that the Government should issue premium bonds.

Rhodesia.—The gold returns for March reflect the result of the strike, the figures being 31,995 oz., as compared with 40,816 oz. in February, and 45,779 oz. in March, 1920. The other returns were as follow: Silver 10,085 oz., copper 248 tons, arsenic 21 tons, coal 33,084 tons, chrome ore 11,767 tons, asbestos 1,990 tons, mica 8 tons, and diamonds 21 carats.

The depression in the copper market has had a serious effect on the financial position of Falcon Mines, which was never very strong. At the meeting held early this month, it was announced that £50,000 was required to pay income tax, debenture interest, and other liabilities, while over £70,000 would have to be provided next year for the redemption of the balance of the debentures. Unless the price of copper improves before long there will be no alternative but to stop work at the mine. The report now issued covers the year ended June 30, 1920, and shows that 168,675 tons of ore was treated for a yield of 2,706 tons copper, 30,942 oz. gold, and 61,812 oz. silver, realizing £452,298. The working cost was £350,599. After taxes, debenture and other interest, and other items were deducted, the profit for the year was £66,759, out of which £30,000 was devoted to debenture redemption. During the six months July to December, 92,188 tons of ore yielded 1,556 tons of copper, 17,604 oz. gold, and 35,445 oz. silver. The ore reserve at June 30, 1920, was estimated at 609,000 tons averaging 4·85 dwt. gold and 2·07% copper. The bottom levels are in disturbed ground, and a good deal of development will have to be done to prove them in depth. On the 11th level the ore-body is estimated to be 220 ft. long and 40 ft. wide, averaging 5 dwt. gold and 1·9% copper, together with a western shoot 70 ft. long and averaging 6·6 dwt. gold and 1·9% copper over 57 inches. On the 12th level, 180 ft. of ore 33 ft. wide and averaging 3·7 dwt. gold and 2·45% copper has been proved, but this is not the full extent.

In February we briefly recorded that developments in depth at the Lonely Reef gold mine continue good. The report for 1920, now to hand, shows, however, that though some very rich ore was discovered during the year in the upper levels, the ore disclosed in the bottom levels is of considerably lower grade than that developed during the previous year. Consequently the reserve, while being maintained as to tonnage, is lower in gold content, the actual figures being 202,845 tons averaging 20·8 dwt. per ton, as compared with 199,739 tons averaging 23·54 dwt. Another point of interest in connection with the bottom workings is that the dip is gradually decreasing, and consequently the cross-cuts from the incline shaft which follows the pitch from the 9th level become longer at each succeeding level. It is intended therefore to sink a new incline under the lode at the 24th level. The consulting engineer also mentions that the supply of firewood suitable for boiler furnaces is exhausted, but that there is abundance of wood suitable for the produc-

tion of gas. It has therefore been decided to substitute steam power by gas engines.

West Africa.—The report of the Fanti Consolidated Mines, Ltd., for 1920 makes reference to the progress made in developing the manganese property at Dagwin. This property was to have been floated as a subsidiary, but the attitude of the Inland Revenue authorities with regard to Excess Profit Duty made it inadvisable to pursue this policy. It was therefore decided that Fanti Consolidated should do the development and equipment itself. Additional shares were issued for this purpose, and an output of 200,000 tons per year has been arranged. The company has a contract for the delivery of 100,000 tons per year for five years at a guaranteed minimum profit of 7s. 6d. per ton, and this contract is renewable for two further periods of five years each. The total amount of ore shipped during 1920 was 41,546 tons.

Nigeria.—The Nigerian Chamber of Mines has been in communication with the Nigerian Government with a view of securing some measure of assistance or protection during the present times of stress. As a result, certain temporary concessions as regards rents, royalties, and working conditions have been granted by the Government: (1) Mining lessees to be released temporarily from labour obligations; three months' notice to be given by the Government before these obligations are again inforced. (2) Until further notice mining rentals on land not worked to be reduced to 2½% of existing rentals, and mining rentals on land worked to 50% of existing rentals. (3) A new and more favourable scale of royalties to be adopted which will afford appreciable relief during the time that the present low price of tin continues. Efforts to obtain a reduction of railway rates on the transport of tin concentrates were not successful.

The Mongu company announces that operations are now confined to the bucket-dredge, and that sluicing and calabashing have been suspended during the depression in the tin market. Prospecting also has been stopped, as the company has extensive proved areas. A small amount of tributing is being continued. The report for 1920 shows that 350 tons of concentrate was won by sluicing and calabashing and 140 tons by dredging. The sales of concentrate brought an income of £98,925, and the profit was £39,263, out of which £9,000 has been allocated for taxation, and £11,607 has been distributed as dividend, being at the rate of 12½%. Under present conditions the directors are wisely keeping a large balance in hand.

Australia.—The output of gold throughout Australia for the year 1920 is given in the accompanying table, together with the figures for 1919. It will be seen that all the states show a diminution except Victoria. In the latter state the revival of activity at Bendigo has been the chief factor in an advance.

	1919. Oz.	1920. Oz.
Victoria	135,428	152,792
New South Wales .. .	65,839	48,907
Queensland ..	120,885	114,181
West Australia	734,067	617,842
South Australia . ..	3,224	3,000
Northern Territory	829	800
Tasmania	11,000	6,170
	1,071,272	943,692

The Kalgurli ore is now exhausted, and the directors have given instruction that the mine shall be closed and the assets realized. This mine was smaller than some of its neighbours at Kalgoorlie, but it was highly profitable, having returned excellent dividends from 1903 to 1916. It is a grateful duty to record that the direction and the management were always of the best.

The Ivanhoe treated 154,920 tons of ore during 1920, for a yield of 57,471 oz. of gold, figures not greatly different from those of the previous year. The gold premium, however, brought a larger income, £346,293 being received, of which £102,000 was premium, as compared with £291,219, of which £41,220 was premium; while, on the other hand, the working cost was 3s. 7d. per ton higher. The net profit was £65,725, out of which £65,000 has been distributed as dividend, making 6s. 6d. per £5 share. It will be seen that, but for the premium on gold, there would have been a loss on the year's working. As regards development, ore is still being found in the operating levels, but in the workings below 2,420 ft. prospecting still gives negative results. The reserve is estimated at 861,786 tons averaging 34s. 4d. per ton, par value, as compared with 972,387 tons averaging 33s. 9d. per ton the year before. It is clear that, with the labour position as it is, the future of the mine depends entirely on the gold premium.

Another dispute has occurred at Kalgoorlie with the firewood cutters, so some of the mines, including the Ivanhoe and Golden Horse-Shoe, were shut down for a short time.

The Fremantle Trading Company, which works silver-lead mines in the Northampton district and also a custom smelter, has been obliged to cease smelting owing to the closing-down of the outside mines. The company's own mines are also necessarily closed, but are being kept in good condition.

The output of metals and minerals in Tas-

mania during the year 1920, together with their market value, are given in the following table:

		Output.	Value £.
Gold	oz.	6,246	29,796
Silver	oz.	623,359	166,797
Osmiridium	oz	2,009	77,114
Lead	tons	3,855	142,268
Copper	tons	4,791	528,237
Tin	tons	1,310	369,362
Coal	tons	75,429	64,005
Wolfram	tons	71	13,626
Scheelite	tons	105	17,905
Bismuth	cwt.	2	9
Shale	tons	140	172
Iron Pyrites	tons	4,440	7,346
Barytes	tons	1,048	4,136

India.—A new agreement has been made between the gold mines and the Indian Government with regard to the disposal of the gold produced. This is the third arrangement made during the last two years. It is gratifying to know that the mines will by its means reap full benefit from the premium, and be no longer hampered by regulations which were in the nature of halting concessions.

The Ooregum is the deepest of the Indian gold mines. In Taylor's section a winze is being sunk on the 62nd level, which is 5,700 ft. vertically below outcrop. In Oakley's section work is being done on the 64th level, 6,000 ft. vertically below outcrop. In both cases fairly good results are being obtained. In Bullen's section the lode contains much pegmatite, which is barren, but the quartz ore gives good assays.

At the Nundydroog, 102,431 tons of ore was treated during 1920, and 71,531 oz. of gold was extracted, realizing £365,568. The working profit was £109,781, of which £35,962 was written off for plant and shaft-sinking, £31,000 was paid as income and corporation tax, and £14,150 was distributed as dividend, being at the rate of 6d. per 10s. share. As will be remembered, the company was reconstructed in November last in order to provide the capital required for deeper sinking.

The Cordoba Copper Company disposed of its mines in Spain over a year ago and took options on copper properties in Chota Nagpur, India. The report now issued shows that a large amount of prospecting has already been done. At the Surda properties two shafts are being sunk in the neighbourhood of the old workings. At Mosaboni two old shafts are being continued and two new ones are being sunk also; one of these has already intersected a lode at 100 ft. showing copper sulphides. At Dhobani three shafts are being sunk, and one of them is in a lode containing oxidized copper ores. It will be remembered that these properties formed part of the original options acquired by the Cape Copper Co., whose Rakha Hills mine is to the north-west. The apatite deposits described by Mr. Murray in the April issue are to the south-east, and the village of Mosaboni is marked on the map accompanying his article.

Borneo.—The British-Borneo Petroleum Syndicate is issuing 260,000 new shares of 10s. each, thereby increasing the capital from £120,000 to £250,000. The object of the new issue is to enable the company to take advantage of many opportunities for profitable business. The syndicate has concessions in British North Borneo, Brunei, and the Klias Peninsula. The D'Arcy Exploration Co., a subsidiary of the Anglo-Persian Oil Co., had an option on these properties, except part of the British North Borneo concessions; recently it has announced its intention of exercising its rights in British North Borneo and of making full geological examination, but it has renounced its rights on the Brunei and Klias Peninsula concessions. The latter properties are not sufficiently extensive for the Anglo-Persian, but they are now being considered by other parties. The part of British North Borneo not covered by the D'Arcy Exploration Co. is leased to the Kuhara Mining Company, of Japan, which is conducting extensive exploration. The syndicate has interests in the Apex (Trinidad) Oilfields, Ltd., and in the London & Midland Oil Company, which is operating properties in Roumania. The syndicate also has interests in Tuxpam, Mexico, and in South America.

Cornwall.—The passing of Tincroft is an event to be recorded with mixed feelings. It is difficult to say when this mine was originally opened, but records show that on re-starting in 1833 the depth was 136 fathoms. It was amalgamated with Carn Brea in 1896, but the year's balance of the joint working was seldom on the right side, owing to the low grade of the ore. On two occasions the high prices of metals brought profits, on the latter occasion arsenic helping notably. Perhaps if re-arrangements of underground methods had been instituted in early days, better results might have been obtained, but the prospects were never sufficiently promising to attract the necessary large supplies of capital. High costs and low metal prices have lately combined to create a serious adverse balance. So the mine is shut down and the lease is to be surrendered on June 30. At the meeting of shareholders held on April 26, Mr. James Wickett, the chairman, said Tincroft was the only mine with which he was connected that had given him worry, but he was grateful for the profits that had been earned many decades ago, for they had contributed

largely to his father's income and had brought many substantial and enduring advantages to the family. The chapter on Tincroft should not be finally closed without recognition of the services of the owner of the royalties, Lord Clifden, and his agent, Mr. John Gilbert, in helping to keep the mine alive during recent years.

Canada.—It is reported that the W. B. Thompson group have abandoned their option on the Flin-Flon copper mine, near The Pas, Manitoba. Previously Messrs. Hayden, Stone & Co., of Boston, had dropped their option after full examination. It is now stated that the Mining Corporation of Canada, which was associated with the W. B. Thompson option, is negotiating for an option on its own account. As readers of the report contained in last month's MAGAZINE are aware, the ore-body though large is of low grade, and the metallurgical problem is not of the simplest.

United States.—The quarrel between Mr. Karl Eilers and the Guggenheims over the control of the American Smelting & Refining Company has ended in a victory for the Guggenheims, who, however, have thought it politic to elect to the board several representatives of outside financial interests, instead of confining the directorate to their own immediate entourage. Among the directors elected in this way are representatives of the Guaranty Trust, the Royal Bank of Canada, and the Irving National Bank. The Guggenheims held 682,223 proxies, and Mr. Eilers 202,479. Mr. Eilers is the son of the late Mr. Anton Eilers, and like his father was concerned in the metallurgical management; but he has also a large financial interest. During the last year or two he has protested against some points in the Guggenheim methods, and has sought to force their hands. A year ago the Guggenheims were able to veto his re-election to the board, and his connection with the company then ceased. His grievance, to put it briefly, is that the Guggenheims, though they hold the control, have parted with most of their shares, and that they have used the "A. S. & R." for their own purposes in the stock market. Thus it is alleged that the company has been left with unprofitable smelting contracts, while the Guggenheims have benefited by the rise in the shares of the companies with whom the contracts were made. At this distance it is impossible to examine into the intricacies of what is, after all, only a personal dispute.

The output of quicksilver in the United States during 1920 is estimated at 13,070 flasks of 75 lb. each, compared with 21,348 flasks in 1919. The chief producing states were California with 9,366 flasks, and Texas with 3,601 flasks. The decline in prices was even more marked, the figure falling from the maximum, $102 per flask, in April to $49 in December.

Ecuador. — The Anglo-Ecuadorian Oilfields, Ltd., was formed two years ago to acquire the whole of the Ecuadorian property of Lobitos Oilfields, which itself operates in Peru. News was received last month that oil had been struck in the first well at a depth of 2,543 ft. The flow and oil are reported to have much the same characteristics as those of the wells operated by the Lobitos company.

Roumania.—The Roumanian Consolidated Oilfields, Ltd., is issuing £100,000 debentures to provide funds chiefly for the completion of the new refinery. The share capital of the company is being concurrently increased so that conversion rights may be given to debenture-holders. It will be remembered that the Appeal Court dismissed the claim of the company for compensation for the destruction of the oil-wells and plant during the German advance, holding that the claim should be lodged with the Roumanian Government. The British and French Governments have since agreed to pay £300,000 as their contribution, and they may increase this amount under the guarantee to the Roumanian Government. The total bill for damage is now estimated at about £1,000,000. The company has issued a circular giving an account of the present position. Since the armistice all the surface works have been re-erected, 20,000 tons of tank capacity has been constructed, and 130 kilometres of pipe-line has been relaid. The new refinery has double the capacity of that destroyed. There are now seventeen producing wells and twelve wells in course of drilling. The output since the resumption of operations has been 40,000 tons. It is hoped that the pre-war rate of output will be reached by the end of the year, and that by means of the new drilling campaign this rate will be doubled in the near future.

The production of oil in Roumania during 1920 was 1,031,030 tons, an increase of 200,000 tons over 1919, and comparing with 1,700,000 tons before the war.

Spitsbergen.—The Northern Exploration Company has offered £150,000 Secured Notes to shareholders, with the object of keeping this organization alive, and in particular of developing certain coal deposits on the east coast. These notes carry 8% interest, and are redeemable at 25% premium at the end of three years. The directors will not go to allotment unless £50,000 is subscribed. At the time of writing the result of this offer is not known.

NOTES ON OPEN-CUT MINING.

By R. S. BOTSFORD, A.R.S.M., M.Inst.M.M.

The Author discusses some recent advances in practice in open-cut mining.

OWING to the high cost of labour the close study of the economics of open-cut mining by means of steam shovel has become a necessity. Some points are considered in this paper, and particulars are given of certain experience and methods of working, particularly in connection with stripping overburden and mining iron ore and coal.

Open-Cut Iron Mining.

When the dipper of the largest stripping shovel is pulling up through the bank, there is a pull of over 40 tons concentrated in the cutting edges of the teeth, and there are few moderately hard materials that can withstand it. With hard clays and shales, it is a question of calculation whether the added cost of explosive and drilling as a preliminary preparation to loosen the ground is worth the increased capacity thereby attained as against greater wear on the machine. For example, stripping heavy clay in the Mesabi Iron Range in Minnesota cost, without blasting, 30 cents per yard, and was very hard on the shovel. However, explosives cost 39 cents per pound, of which $\frac{3}{4}$ lb. per yard would be necessary, so that it was better to change the teeth of the dipper every day to have them sharpened and to avoid blasting. When blasting is required it is not necessary to break the rock up anything like so small as is required for hand labour. It is very difficult always to have empty wagons at the shovel ready to be loaded. Most delays are caused by waiting for empty wagons. Equally important with the actual stripping operation is the management of the dump, for time can be lost there just as well as in the open-cut, and without wagons the operations cease, although costs and overhead charges continue.

During the summer of 1919, A. Guthrie & Co., working on a stripping contract close to Coleraine in the Iron Range, at the Danube pit, got a record of 231,000 yards in the month for their Model 300 shovel and a record of 357 cars per 10-hour shift using 16-yard air-dump cars. On account of the greater capacity obtained with their equipment it cost them about 20 cents per yard instead of 30 cents per yard. Moreover, they averaged 317 cars in the day shift and 318 at night, and the cars averaged $17\frac{1}{2}$ yards bank measurement. From observation I attribute their record to good management and attention to essential details. From experience they endeavour to standardize their operations, and have come down to the 16-yard Columbus car (air-dump) because they find that there is only 25% of the upkeep or repair in comparison with the larger 20-yard car. The locomotive they favour, after 3 or 4 years' experiment, is the Baldwin "Switcher type," which weighs 78 tons.

The use of the large revolving stripping shovel has permitted the development of a special kind of cut of which they take advantage, materially modifying the working conditions. (See Fig. 1).

Arrangements are made for loading on both sides of the cut, with track on either side communicating with the dump, so that loading goes on continuously, and at 35 to 40 ft. above the working floor. The cut is over 100 ft. wide at the working floor and exceeds 160 ft. wide at the top at the level of the tracks. While the shovel will deliver on tracks 200 ft. apart, it is well to have about 10 ft. excess reach in case of any spill on the track which the dipper can push off, or in case a car gets derailed, when assistance can be given to the train crew.

The next cut is taken alongside the first, but leaving the loading track in position between the two cuts, and the new cut has two loading tracks, one each side as before.

When descending to the next horizon, 35 ft. lower, the shovel digs right under one of the loading tracks, as it is preparing to do in the photograph, with a new loading track on either side, on the floors of the earlier cuts, and now takes in the ground including that supporting the track right up to the surface, and loading on to the tracks 35 ft. from the surface, whence it is hauled out on a $2\frac{1}{2}$% slope (see Fig. 2). This is done from a depth of approximately 70 ft. The section of the working cut is so large that it is only necessary to move up about once a day. One of the great advantages is that the trains are hauled out on the level until the 70 ft. horizon is started, and then only from a depth of 35 ft. The substitution of one large stripping shovel in place of standard railroad shovels reduced the pay-roll by 150 men, mostly in train crews and labour moving tracks as well as locomotives. The $2\frac{1}{2}$% slope is important and must not be exceed-

FIG. 1. THE DANUBE IRON-ORE PIT, COLERAINE, MINNESOTA.

ed even for a short distance, or fewer cars can be carried in the train. If less than $2\frac{1}{2}\%$, then a longer approach is required. Much less train equipment is required by this method in comparison with the standard railroad-type shovel loading on a track alongside, for a given depth. The number of cuts and consequent shifting of tracks and operations is a mere fraction of the ordinary method with the standard shovel, and a great deal of money is saved.

FIG. 2. LARGE STRIPPING SHOVEL ABOUT TO START A NEW CUT AT A LOWER HORIZON.

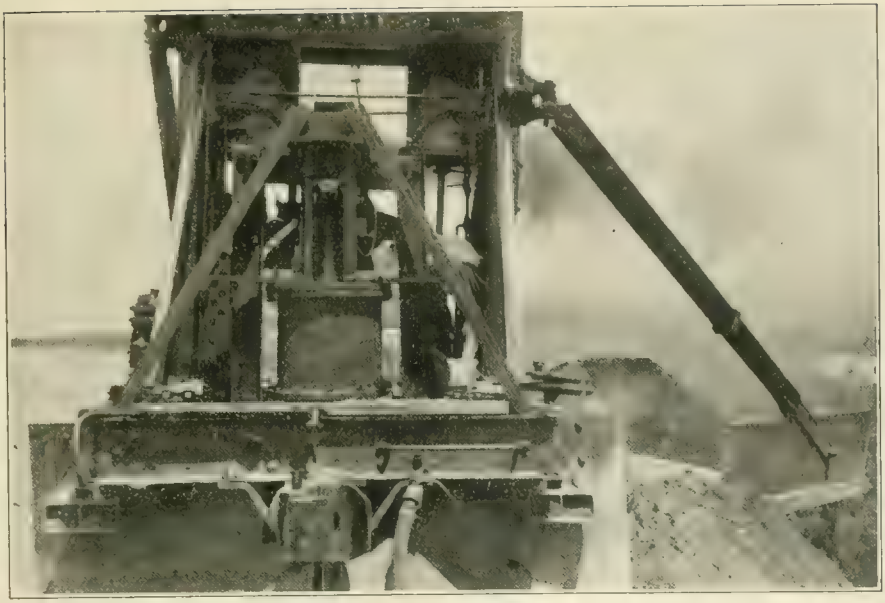

FIG 3. SPREADER IN OPERATION ON THE DUMP.

On the dump, the operations consist in dumping the train of automatic air-dump cars, operated from the locomotive, which may occupy a minute or more. Occasionally the spreader (Fig. 3) is run over the track to push the ground over the edge of the dump when necessary. Ultimately the track must be shifted, which is done in the daytime, by means of the track-shifter (Fig. 5). This moves the track out about 4 ft., and the operation goes on at about two miles an hour. Fifteen men during the day and three at night will look after the dump, whereas without the track-shifter more than three times the number would be required during the day. Thus the three machines or contrivances, (1) automatic air-dumping, (2) spreader, (3) track-shifter, do all the heavy work on the dump.

In the pit the most desirable conditions are established with a permanent approach down the centre and a run-around at the further end when this can be arranged. Where the pit is long and narrow it is necessary to use a zig-zag

FIG. 4. LARGE SHOVEL STRIPPING OVERBURDEN, AND A SMALLER SHOVEL FOLLOWING REMOVING THE COAL UNDERNEATH.

to descend to the working level. If this is on a bank which is a receding working face, there is a constant shifting of the main track as the face recedes, which closes down the work when moving the main track and is to be avoided at all costs.

In mining the comparatively soft hematite, it is first loosened with explosive and then loaded into 50-ton cars with bottom discharge. Here conditions are different, as a regular grade of ore must be maintained for shipment, and different parts are worked according to the grade called for. For this reason the smaller but equally powerful railroad-type shovel is used, as it can be easily moved around on the standard gauge track. Further, there is not so much capital tied up when one is laid off for two or three weeks.

There are approximately 200 steam shovels working in the Iron Range, the greatest iron-field in the world.

The Hull Rust pit is about 185 ft. deep, one mile across, and one and a half miles long. It is the biggest artificial hole in the world, and usually too full of smoke to obtain a good photograph. It is more than probable that the bigger operations here will be carried on with electric power, as great economy would result. For this reason due consideration should be given in laying out a new property to the desirability or otherwise of using electric power in the first instance. At the Hull Rust pit the overburden is about 100 ft. thick, and where there is a proportion of 3 of ore to 1 of overburden the ground is reserved for steam-shovel mining, and therefore unavailable for dumps, instead of underground mining which is also being carried on. A slope of about 1 to 1 is arranged for from the side lines of the property, and a berm or bare space above the ore of 20 or more feet in width to avoid having the downwash from rain carrying overburden on to the ore.

Stripping Coal by Overcasting.

Much of the expense connected with steam-shovel mining may be eliminated where conditions are similar to those encountered by Robert Holmes, at Danville, Illinois. Over a large part of the state there is a bed of coal too close to the surface to be mined by underground methods, and until he developed the present method, stripping was too expensive. The nearly horizontal layer of coal is covered with approximately 30 ft. of overburden which can be excavated with a shovel (Fig. 4). Briefly he develops a long working face along which the large revolving stripping shovel operates, digging the overburden and casting it back to the extreme reach of the shovel, uncovering the coal and disposing of the overburden in one operation. As the shovel advances along the trench it is followed by a smaller shovel which digs up the coal. The coal is removed along the trench on a narrow gauge track, so that when the large stripping shovel returns digging along the cut there is a fresh strip from which the coal has been removed for the disposal of the overburden.

Under the conditions of labour at Danville, it would be impossible to dig out this overburden and remove it in cars for less than 20 cents per yard. Digging and casting back to the final resting place is accomplished for 9 cents per yard. There is, for example, no expense for trains and dump, nor diminished capacity due to delays for empty cars. The only delay is at the end of the cut, at long intervals, required for the removal of the coal right up to the shovel before returning. This may amount to four days more or less, depending on how near the coal-removing operations have kept up to the shovel. Other conditions being satisfactory, it would be all right to mine *two* layers of coal or other material, with a few feet of dirt between, casting back the layer of valueless material between the two layers of coal before the large stripping shovel returned.

With a fixed price of \$3·75 per ton of coal delivered in the railroad cars at Danville workings, a satisfactory ratio of 1 of coal to 6 of overburden could be mined with big profits when many underground mines were closing down, for the cost was about \$1·00 per ton of coal. The cost of mining is absurdly small in comparison with underground mining or removing the material to a dump, and the profits proportionately large. It would not be worth while stripping such a low-priced product as coal, less than approximately 4 ft. thick. The limit of overburden at the rate of not more than 6 to 1 at Danville depends on the limit of the machine, which has a 90 ft. boom. Plans are ready for one with a 125 ft. boom. Naturally the thickness of bed of valuable material (coal in this instance) affects the height of material cast back, as a thicker bed on which the stripping shovel runs, after removal, leaves more room for disposal of the overburden, without the latter getting too high for the stripping shovel. With 8 ft. of coal, about 45 ft. of overburden would be the limit with a Model 300, which is the largest machine. It can propel itself over the surface of the coal on its tracks to a limit of about 20° slope, which is approached in the undulations of the coal bed. Many engineers

will recollect within their experience places where such stripping methods are applicable, in iron ore for example. Four thousand five hundred yards in a 10-hour shift as an average would be a reasonably moderate output to expect from such a large stripping shovel with an 8-yard dipper, and it is easily exceeded to the extent of 50% or more depending on the operator. Not being dependent on cars, or strikes, a good output can be maintained. The only difficulty they had at any time was to get railroad cars to take their product away, their output being considerable with several stripping shovels. The expense of operation depends, in stripping, on the cost of power and labour and conditions in the particular part of the world where the operations would be carried out, and almost anywhere would be less than those indicated, in some places a mere fraction.

In these coal-stripping operations there is not much to choose between electric shovels and steam shovels. Both are used. Where there is no electric power plant or power available, then the advantage is with the coal which is at hand for firing.

In cold weather, special precautions must be taken to keep the feed-water pipe-line from freezing, fires being built around it at intervals. A less number of men are required on the electric shovel, there is no attendant or expense of banked fires when shut-down at night, and there are no ashes or water dropped from the electric shovel as from the steam shovel, which must be cleaned up before mining the coal. The water, of course, forms ice in winter which must be dug up and removed.

Coal stripping by overcasting is a live proposition, and is taken up wherever suitable properties and equipment can be brought together under favourable conditions.

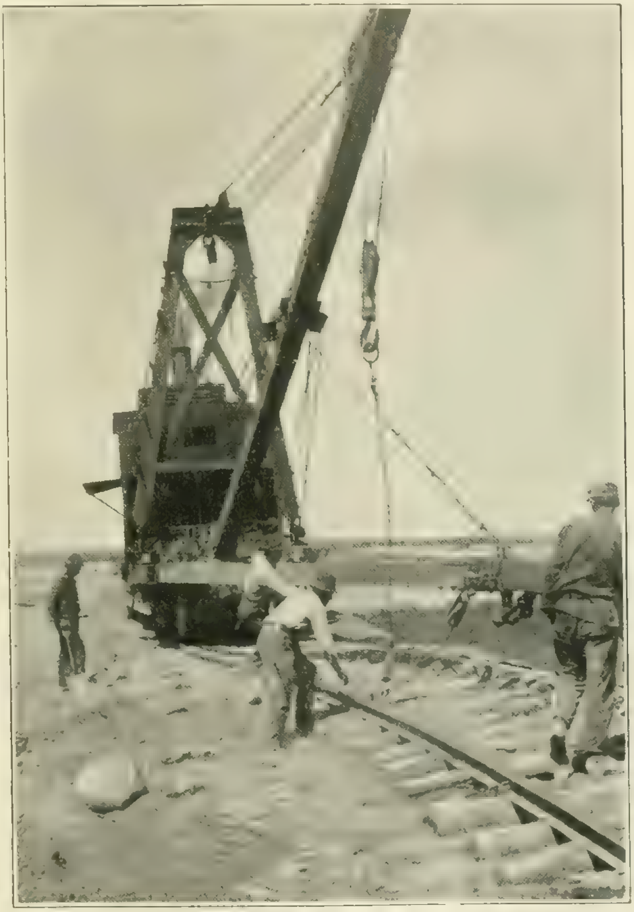

Fig. 5. Track-Shifter in Operation.

THE ORIGIN OF PRIMARY ORE DEPOSITS.

By J. D. KENDALL.

The Author contributes to the discussion on Dr. J. Morrow Campbell's recent paper on this subject.

IN the November issue of the MAGAZINE there appeared an abstract of a paper with the above title, read before the Institution of Mining and Metallurgy by Dr. J. Morrow Campbell, which interested me so much that I obtained a copy of the paper, and having read it ask to be allowed to submit a few observations thereon.

The paper contains so much that invites criticism that it would require more space than the original paper to deal with it fully. I shall therefore confine my remarks to such parts of it as seem to embody the author's ideas on the formation of ore-bodies.

Taking the paper as a whole I was perhaps most struck by the absence of drawings. The English language has great power, but it cannot describe with precision many of the features which must be accurately realized in investigations as to genesis. This can be much better done by accurate drawings which limit the exercise of the reader's imagination, and generally present the facts of form and position much more concisely.

A further surprise is the little that is said by way of showing how the suggestions offered succeed in explaining the well-known features of the different classes of ore-bodies.

The first item to which I should like to refer is concerned with crust-forming. Although not directly connected with ore-formation, yet the writer of the paper arrives at certain conclusions in connection therewith that form the kernel of his views as to ore-deposition. On the second page we read: "It has been the custom of geologists to assume the existence of two types of primary magma, the granitic above and the basaltic below. Others believe that the initial crust of the earth was basaltic and that a granitic magma developed beneath it. The truth is probably reached by assuming the existence of only one primeval magma of intermediate composition—dioritic or andesitic—which on differentiation yielded both the typical granitic and basaltic magmas."

That the primeval magma had an intermediate chemical composition, when considered in connection with granite and the basic plutonics, is probably true. But it seems clear from a consideration of the chemical constitution of the plutonic rocks and of that of the minerals composing them that, as the latter formed, differentiation would begin, and therefore it is not possible that the minerals in diorite could produce granite. This is evident when we look at the mineral composition of either the plutonic or volcanic rocks. Granite contains a large percentage of free silica; diorite contains much less, and then only in the variety called quartz-diorite. The same sort of argument leads to the conclusion that the basic rocks did not come from a substance having the mineral constitution of diorite. If the free silica of granite was primarily combined, what has become of the bases with which it was united? They are not found in the more basic rocks.

Differentiation of such a magma as that referred to above was probably due, in large measure if not entirely, to differences of specific gravity of the various minerals formed from the syntectic, combined with the effect of falling temperature. Those minerals having a less specific gravity than the average would rise; those that were heavier would fall. As a consequence of these opposite movements, and the interference arising from them, some portions of the minerals might and probably would be locked up in positions higher or lower than those due to their specific gravities. The falling minerals would be absorbed in the hotter syntectic below, to be again crystallized and separated from the more acid minerals. This process would be repeated again and again as zone after zone, downwards, cooled to the necessary temperature. The fusibility of the felspathic minerals is—with the exception of anorthite—inversely as their specific gravities.

On the second page, also, we are told that "solidification commenced at the surface by radiation of heat as ice does on water, but the result differed in that the solid was heavier than the liquid, therefore upon being broken up by tidal and storm movements it sank and was re-melted. This cycle of crust formation, foundering, and re-fusion, proceeded until the temperature of the silicate sea to a depth of probably several miles was considerably lowered." In writing this passage the author of the paper seems to have lost sight of the operation of differentiation, which must result in increasing basicity and specific gravity downwards, and prevent the comparatively light acid layer

formed on the surface from sinking as suggested. But apart from this theoretical difficulty it has been ascertained by Barns (United States Geological Survey, Bulletin 103) that the broken crust formed on molten diabase would not sink although heavier than the hot liquid below it. There is also the further objection that the suggested foundering and re-fusion, if the former were possible, by producing circulation would prevent the differentiation which the writer of the paper admits to have occurred.

At the foot of the third page of the paper is a paragraph more than usually laden with assumptions. Some of these assumptions are admitted; others are put forward as if acknowledged facts. We there read "that granitic magmas on solidification give off an aqueous mother-liquor. The primary crust was largely granitic, so we have to assume that it gave off a similar liquid. Such acid liquors invariably carry the bulk of the ore-minerals originally present in the granitic magma, so we must assume that large quantities of ores were ejected at the surface of the primary crust. These would be mostly tin, tungsten, gold, copper, zinc, and lead. Probably none of these ore deposits have survived. They must have been denuded and dispersed in sediments and in aqueous solutions."

The paper does not give the evidence which induces the writer of it to say that granitic magmas give off an aqueous mother-liquor. But I assume he refers to such occurrences as that at Clifton, Arizona, where the limestone for several hundred feet from the contact with granitic and dioritic porphyry has been replaced by garnet, etc. There is not, however, any conclusive evidence that changes like that—from calcareous to silicate rocks—were effected by solutions which came from the newly erupted magma. When the igneous intrusions occurred the limestone would be severely ruptured in many directions and to some distance from the heated rock. Moreover, contraction of the igneous rock in cooling would produce numerous other openings and fractures. Vadose waters charged with the necessary compounds could circulate through the passages so produced and might, in time, effect the alteration that has occurred at the several points. The circulating waters in their devious courses through the rocks might rise in part through the cooled magma and take up from them some of, or all, the silicates necessary to the metamorphism.

The great difficulty in the way of ascribing these non-metallic replacements to the action of magmatic waters is their interrupted occurrence along the contacts. In the Marble Bay copper mine, on Texada Island, British Columbia,* there is an interesting example of these so-called metamorphisms by magmatic waters. The mine is in limestone in the neighbourhood of three small outbursts of diorite-porphyry. The ore-body is about 200 ft. long, and occurs alongside a fault which is nearly at right angles to the perimeter of the largest mass of igneous rock. The mine has been opened to a depth of nearly 1,200 ft. by 13 levels mostly 100 ft. apart. A small dyke intersects the workings at a depth of 260 ft., also at 460, 560, and 660 ft. In the 760, 860, and 960 ft. levels there are several small dykes, and in the workings at 1,060 and 1,160 ft. there is a much larger intrusion, about 30 ft. wide. These dykes most probably are all branches from the main body of igneous rock, of which, however, there is no indication in the deepest working. The ore-body at the surface is only about 200 ft. from the near edge of the largest boss, and it goes down nearly plumb, so that the igneous rock must be very steep on that side. The ore is chalcopyrite and bornite, and occurs more or less interruptedly in a gangue of andradite, diopside, tremolite, actinolite, epidote, calcite, and a little quartz. Fig. 1 shows the mode in which the different minerals occur in some parts of the deposit. Fig. 2 is a section exposed at the surface, showing the manner in which the ore occurs in the andradite over a larger space than Fig. 1.

These gangue minerals traverse the limestone in a very irregular manner, but there is no indication of an increase in the extent of them toward the main igneous mass. Between the dykes seen in the workings and the limestone through which they have been forced there is frequently no indication of secondary silicate rocks. The formation of the gangue minerals has taken place at different times, as shown by Fig. 1; that of the chalcopyrite and bornite followed the andradite, etc.

If it be supposed that the solution or solutions which give rise to the replacement of the limestone exuded from the diorite-porphyry, that would not justify us in assuming that similar or other solutions were given off by the primeval acid crust, as suggested by Mr. Campbell, for the conditions in the two cases would be entirely different. In that of the igneous outbursts at Clifton and Marble Bay the fractures in the limestone would form very small means of escape for the previously confined

* "The Auriferous and Argentiferous Copper Ores of Southern British Columbia," by J. D. Kendall. *Mining Journal*, 1900; also "Texada Island, B.C.," Memoir 58, Canadian Geological Survey.

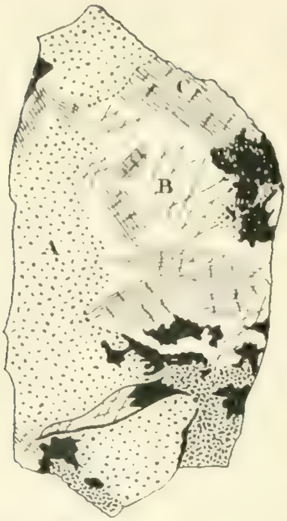

Fig 1. A - Andradite
B. - Calcite
C. - Actinolite
- Chalcopyrite
- Bornite

Fig. 2. A = Andradite
B. = Limestone
Chalcopyrite & Bornite

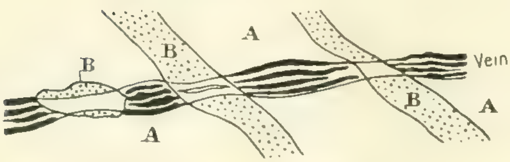

Fig. 3. A = Granite. B = Aplite.

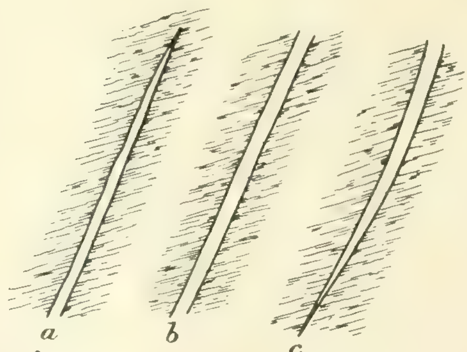

Fig. 4.

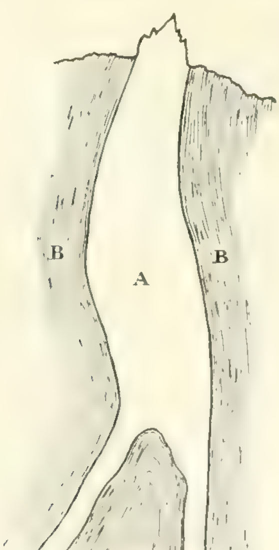

Fig 6. A = Ore-body B = Wall-rock

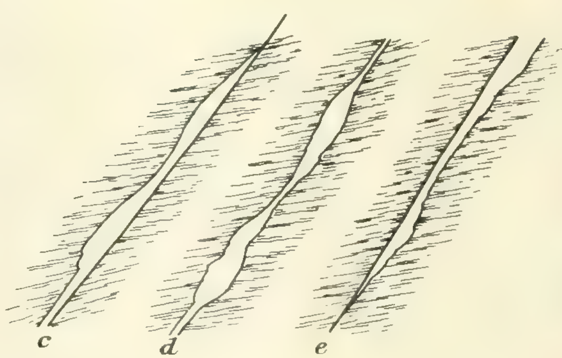

Fig. 5.

magmatic waters and gases, unless these fractures extended to the surface. If they did so, the outward rush of the imprisoned waters and gases would be so rapid that there would not be sufficient time to effect the replacement of much of the limestone before the escaping waters were exhausted. With the primitive crust it would be different. The enormous pressure of about 3,000 lb. per square inch, due to the overlying hydrosphere, would prevent any escape of occluded water with its supposed load of metallic and non-metallic minerals.

If, however, such an aqueous, silicious effusion as is suggested by the paper were to be admitted, we should still be confronted by the difficulty of explaining why, according to the supposition, some of the metals, which form an important part of the earth's crust, were subjected to magmatic differentiation, while others, more likely to so act, behaved in an entirely opposite manner. Mr. Campbell seems to have assumed what, in justice to his own ideas, requires complete demonstration.

If the exudation of magmatic waters be considered probable from both the primeval crust and the much more recent rocks referred to at Clifton and elsewhere, there is not any evidence that they were laden with metallic minerals and that the deposition of those minerals, from the latter, formed the respective ore-bodies. In each case, so far as my experience goes, the deposition of minerals was a later event.

Under the heading "Primary Ores" the following occurs in Mr. Campbell's paper: "Primary ores may be defined as those which are derived directly from rock magmas or magmatic liquids." Seeing that the formation of ore-bodies by magmatic liquids is a very debatable subject, it is surely a poor foundation on which to build an important definition. Moreover, it is likely to lead to confusion, the word "primary" having already been applied to syngenetic ores, a definition which is as unsatisfactory as Mr. Campbell's, because it is very doubtful whether any workable ore-bodies are syngenetic if we except the few and unimportant magmatic concentrations described by Vogt at Taberg, etc. The difference between primary and secondary ores is well understood in practice, the latter having been derived from the former. Such being the case it seems to me sufficient to say that "a primary ore is an ore which has not been derived from any other ore." In saying that, there is not any doubtful genetic assertion or implication.

Under the heading "Base Metals" Mr. Campbell writes: "With primary ores of copper, zinc, lead, and antimony, we are faced with the same fact that in the veins along with them quartz is almost always present. There is good reason for believing that the sulphides of these metals came up from magmas in silicic-acid solutions." It would have been much more satisfactory if that reason had been given. As regards the assertion that quartz is almost always present with deposits of base-metal minerals, it seems to me that such an indefinite statement has no ascertained bearing on the genesis of such ore-bodies. Bearing in mind that oxygen and silicon are the two most abundant elements known in the earth's crust, it is to be expected that quartz would have a wide distribution. My experience has been that in ore-bodies occurring in silicate rocks it is almost invariably the most abundant gangue mineral, but in those contained in calcareous rocks its proportion is usually small and often almost nil. Why on Mr. Campbell's supposition should there be this difference?

It would have been useful and interesting if Mr. Campbell had shown how the silicic acid solution produced the many replacement deposits that occur in different parts of the world. I need only mention a few to emphasize the importance and necessity of such a demonstration. Just now I am thinking of the silver-lead deposits at Leadville in Colorado, and of Eureka in Nevada, and also of the copper deposits of Clifton and Bisbee in Arizona. To me it seems an utter impossibility that those deposits and scores of others like them could have been formed in the way suggested in the paper. There could not have been any cavernous spaces into which the silicic acid solution could have dropped its load of metallic minerals as I have shown elsewhere.* Nor could the order in which the different minerals were deposited be accounted for.

As regards the upward succession of ore-minerals, on this part of the subject we read that it is intended to "deal only with ore-minerals occurring in veins deposited therein directly by magmatic solutions, and we may assume them to be carried in silicic acid. We also assume that an open fissure exists, up which solutions pass. After the first inrush the flow of ore-bearing liquid in the fissure is probably slow and at all parts its temperature is a little higher than that of the walls, heat being transferred from the former to the latter. ... The liquid on leaving the batholith carries say tin oxide and chalcopyrite in solution, its temperature falls as it passes upwards, and at a certain point cassiterite commences to deposit

* The Formation of Ore-bodies. Transactions Canadian Mining Institute Vol. xxi., 1918.

and continues to do so upward until all the tin in solution is exhausted. This will take place when the liquid has fallen to a temperature at which it can no longer hold tin in solution.... The same liquid carries chalcopyrite and iron bisulphide as well.... No chalcopyrite was deposited with cassiterite below, but near its upper limit chalcopyrite commences to develop and continues until a point is reached where the temperature of the liquid no longer permits it to hold copper in solution. Here again we have a range of temperature within which chalcopyrite deposits; the hotter limit is nearly coincident with the cooler limit for tin, the two may overlap slightly." This process, I submit, does not explain the cases in Cornwall where tin is found in granite and copper in slate, and it fails most strikingly in that remarkable case mentioned by Henwood† at the Botallack mine in West Cornwall, where a vein passes three times from granite to slate and in each case contains tin ore only in the former and copper ore only in the latter. Nor does it satisfy our desire to know why in the lead veins of Alston, Allendale, and Weardale the galena has been deposited principally in the calcareous beds of the Yoredales. Nor why the copper veins of Butte, Montana, are ore-bearing chiefly in the granite and almost barren in the aplite as shown in Fig. 3.

Fig 8 A Granite. B = Tin Vein

Fig 9. A = Horse

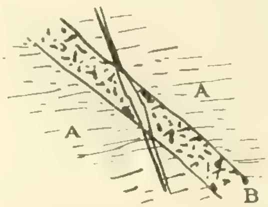

Fig 7 A-Slate B-Elvan

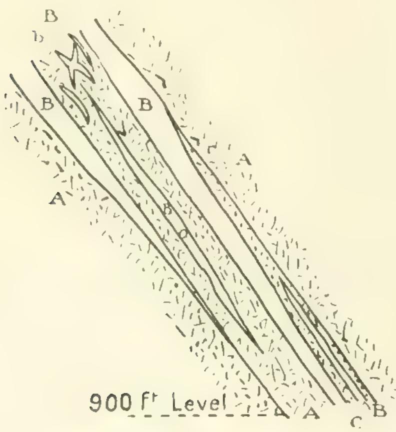

Fig 11 A-Diabase B-Quartz

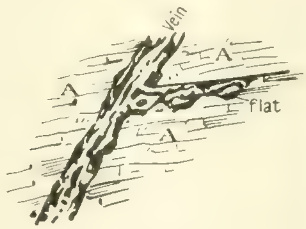

Fig 10 A=Limestone

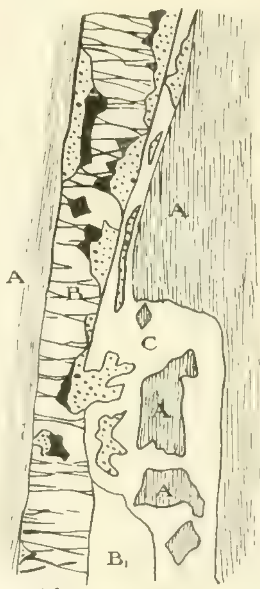

Fig 14. A = Argillite
B. = Quartz (combed)
B1 = Quartz (granular)
C = Bitter Spar
Blende
Galena

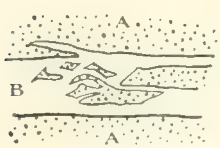

Fig 13 A-Mica Syenite. B=Quartz

Fig. 12 A-Serpentine, B-Diabase C Quartz.

The gold veins of California, like the Beckman and Canada Hill veins, cannot possibly be filled fissures. The former has a dip of only $7\frac{1}{2}$ degrees from horizontal and the latter only 20 degrees. It is to me quite inconceivable

† Metalliferous Deposits of Cornwall and Devon, 1843.

that the hanging-wall rock of either of these veins could have been lifted in such a way, and for sufficient time, as to allow the opening to be filled with a body of quartz. The Canada Hill vein is in places 15 and 18 inches wide, although at other parts it is only a very thin seam. Many other such cases might be mentioned.

The filled-fissure suggestion fails also to show why the pitch of ore-shoots, in veins, is so often parallel to the strata of the adjoining rocks. Indeed it fails to explain all the more important features bearing on genesis, as I will endeavour to show.

space now occupied by the ore-body was not produced by the drawing apart of the rocks after being fractured.

At Wheal Alfred, near Gwinear, Cornwall,* the tin vein shown in Fig. 7 was 6 to 9 ft. wide in the slate above the elvan, increasing in the latter to 25 ft., but decreasing in the slate below to 10 ft. The elvan is about 300 ft. thick. A similar widening occurred on the tin vein, at the 100 fathom level, of the Huel Lovell mine,† in the parish of Wendron, Cornwall, as shown in Fig. 8.

The occurrence of horses in veins, like that

Fig 15. A= Skiddaw Slate B = Quartz

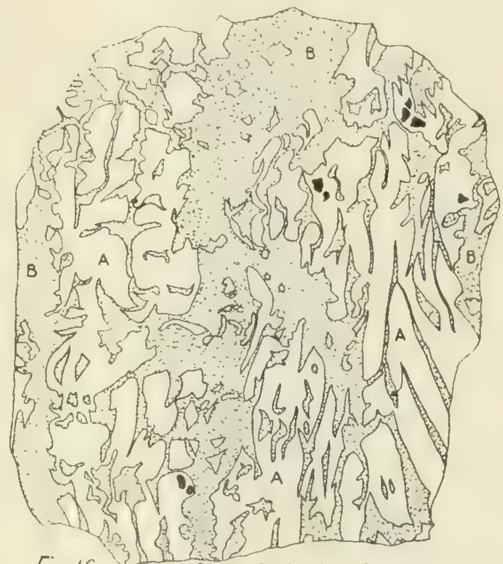

Fig 16 A = Quartz B = Ash rock ◆ = Chalcopyrite

The assumption of fractures opening wide enough to be immediately filled by either silicious or other solutions has soon to be abandoned when we look at the cross-sections of any well-defined veins. Whether an earth-fracture be straight or crooked the two sides, when drawn apart, will in nearly every case be either parallel or slightly converging when seen in vertical section, as shown by *a*, *b*, *c*, Fig. 4. Experience of veins soon shows us that they do not occur in these simple forms, in which the walls are parallel or nearly so, but that they vary in width very irregularly, as shown by the cross-sections *d*, *e*, *f*, in Fig. 5. It is quite impossible for fractures, either simple or compound, to produce openings in rocks having forms like those in Fig. 5. This difficulty is very clearly realized when we look at a cross-section like that of the upper part of the Broken Hill silver-lead deposit, as shown in Fig. 6. It does not require much thought to satisfy one that the

shown in Fig. 9, cannot result from any kind of fracture, the total width of the veins on the two sides of the horse being greater than the width either immediately above or below, that is, at *a*, *b*.

The lead-bearing veins in the Yoredales of Cumberland, Durham, and Northumberland are much wider in the limestones than in any of the shales or sandstones alternating with the limestones. An extreme case of that kind is provided by the "flats" which are found in connection with the Great and other limestones at Alston Moor. A section of one of these flats projecting from a vein is shown in Fig. 10. It is inconceivable that the filling of any kind of fracture could have produced the ore-body shown in this section.

Hundreds of such examples of the *form* of veins might be added in opposition to the filled-

* Geology of Cornwall and Devon, 1839, Sir H. de la Beche.
† Trans. Roy. Geol. Soc. of Cornwall, vol. ix., p. 167.

fissure idea, but I will now refer to a few sections exhibiting the *inner nature* of veins of different kinds. Fig. 11 is a cross-section, in the 900 ft. level, of the Pittsburgh gold vein, in Nevada City district, California. The rock in which it occurs is diabase. The various bodies of quartz forming the vein cannot be filled-fissures. Particularly can this be said of a, b, and c.

Other cross-sections of vein are given in Figs. 12, 13, and 14. Fig. 12 is a cross-section of the Maryland vein, Grass Valley, California. Fig. 13 is a horizontal section of part of the Poorman gold vein, near Nelson, British Columbia. Fig. 14 is a cross-section of the Alamo silver-lead vein, in the Slocan, British Columbia. All these sections are quite irreconcilable with Mr. Campbell's ideas, and such sections might be multiplied to any extent.

I will conclude these observations by reference to two most interesting sections of vein-rock*. Fig. 15 is from the Yewthwaite lead mine near Keswick, Cumberland, and Fig. 16 from the Bonsor vein of the Coniston mine, Lancashire. The complicated mixture of quartz and country rock in these sections shuts out, at once, any suggestion of filled-fissures, while the gradation from silicate rock to pure quartz which occurs in many places is suggestive of the quartz having originated in a manner quite different from that advocated by Mr. Campbell's paper, and which is dealt with in the "Formation of Ore-bodies" by the present writer.

*Mineral Veins of the Lake District, by J. D. Kendall. Transactions Manchester Geological Society, 1884.

BRITISH PETROGRAPHIC NOMENCLATURE.

A summary is here given of the Report of the Joint Committee of the Geological and Mineralogical Societies on the standardization of petrological terms.

In February, 1920, the Geological Society and the Mineralogical Society appointed a joint committee whose functions were to consider whether any standardization of British petrographic nomenclature is possible and desirable, and if so to make recommendations with that end in view. The chairman of the committee is Professor W. W. Watts, and the other members are Dr. J. V. Elsden, Dr. J. S. Flett, Sir Jethro Teall, Dr. H. H. Thomas, Mr. G. W. Tyrrell, appointed by the Geological Society; and Dr. J. W. Evans, Dr. F. H. Hatch, Dr. Arthur Holmes, Dr. G. T. Prior, Dr. R. H. Rastall, and Mr. W. Campbell Smith (Honorary Secretary), appointed by the Mineralogical Society.

The report of this committee has now been issued, and we give herewith a general summary of the recommendations. It is to be noted that no names have been dealt with by the committee that have general undisputed definitions, and that only British nomenclature has come within the scope of the committee. A summary of the report is given herewith, and readers who wish for the complete report should apply for copies thereof from the secretary of the committee or from the secretary of the Geological or Mineralogical Society.

Definitions Recommended.

AMPHIBOLITE is retained for unfoliated or slightly foliated metamorphic rocks of doubtful, or other than igneous, origin. It is composed essentially of hornblende and felspar, often containing various accessories, such as epidote and garnet. EPIDIORITE is retained for unfoliated metamorphosed igneous rocks of doleritic or basaltic composition in which augite has been replaced by hornblende. It usually occurs as dykes and sills. HORNBLENDE-SCHIST is distinguished from amphibolite and epidiorite by the possession of foliated texture.

ANORTHOSITE is retained in the sense of rocks similar in texture to the gabbros and composed almost entirely of basic plagioclase and almost free from ferromagnesian materials.

APLITE and PEGMATITE, when used alone as rock-names, should be used in the sense defined in Harker's Petrology for Students, 1919, pp. 38 and 39, as follows: APLITE "occurs as veins in granite. . . . It is a fine-textured rock with panidiomorphic to granulitic structure, and is somewhat more acid than the associated granite. A characteristic type occurs in connection with the muscovite-granites near Dublin. It consists of microcline, with some oligoclase, quartz, muscovite, and red garnet." PEGMATITES "consist essentially of microcline or orthoclase and quartz, often with white mica and sometimes red garnet. The texture is often extremely coarse, and there is a frequent tendency to the graphic structure." The possession of graphic structure by a pegmatite is not essential. These terms (APLITE and PEGMATITE) may be extended to rocks bearing the same relation to syenite, diorite, &c., as aplite

and pegmatite bear to granite, but, if so used, some indication of their mineralogical composition should be given.

BASALT. The term used alone should not imply the presence of olivine. Basalts containing olivine as an essential constituent should be described as OLIVINE-BASALTS. No definite line is drawn between basalt and dolerite. The distinction depends on coarseness of texture.

CHARNOCKITE. The committee recommends that when reference is made to the "charnockite series" the word "series" be never omitted. Reference to this series of rocks as "the charnockites" is to be avoided. It is further recommended that charnockite as a rock-name be restricted to the granulitic variety of hypersthene-granite of the type locality as defined by Holland in 1893, and to rocks practically identical with this.

DIORITE should be limited to plutonic rocks of intermediate composition, the dominant felspar being an acid plagioclase. More basic rocks consisting of hornblende and basic plagioclase should be classed with the gabbros.

DOLERITE is retained in the sense of a coarse-grained rock of basaltic composition, usually, but not always, hypabyssal. No definite line is drawn between basalt and dolerite. The distinction depends on coarseness of texture.

ESSEXITE is retained for rocks practically identical with, or which show but slight divergence from, the original type of Salem Neck, Essex Co., Massachusetts.

FELSITE is retained for those acid and intermediate intrusives which carry no porphyritic constituent and in which the texture is felsitic.

FELSITIC may be used to designate the cryptocrystalline texture of felsites and similar rocks. The term "microfelsitic," used by certain authors, is unnecessary.

GABBRO includes plutonic rocks of basic composition consisting essentially of a basic plagioclase with one or more ferromagnesian constituents, usually a pyroxene but sometimes hornblende, and with or without olivine.

GNEISS is a medium or coarse-grained crystalline rock possessing some form of parallel structure due either to the uniform orientation of certain tabular or prismatic minerals, or to the presence of wavy discontinuous surfaces indicating a lenticular or phacoidal structure, or of bands of varying mineralogical composition which retain their continuity and parallelism throughout a considerable mass of rock (banded gneisses). Gneisses may be of igneous, sedimentary, or doubtful origin. Those of igneous origin (ortho-gneisses) may have acquired their characteristic structure before, during, or subsequent to consolidation, and only in the last-mentioned class can they be said to be metamorphic rocks. Those of sedimentary origin (para-gneisses) are invariably metamorphic rocks owing to the development in them of new minerals; their parallel structure may in some cases follow planes due to deposition, in others due to deformation. The term "gneiss," when used without qualification, should imply a rock of granitic composition but not necessarily of igneous origin.

SCHIST (crystalline schists) differs from gneiss in being of finer grain, and in possessing a well-marked tendency to split into thin layers, except when puckered or folded by movement subsequent to the development of schistosity. The term carries with it no mineralogical connotation.

GRANODIORITE is to be retained for rocks intermediate between quartz-diorite and granite in which orthoclase, while present as a notable constituent, is always subordinate in amount to the plagioclase.

GRANOPHYRE is retained in the sense in which the term is used by Rosenbusch (1872), and by Harker.

GRANULITE is not to be used in the sense of Michael Lévy, for muscovite-granite. When used as a rock-name it should be used only for rocks with granulitic texture, and should be qualified by prefixing the name of the mineral, or minerals, which characterize the rock.

GRANULITIC texture may be used for that texture of rocks characterized by even-sized and closely-fitting grains. It is applicable to metamorphosed sedimentary and metamorphosed igneous rocks, and, to a more limited extent, to igneous rocks in which the texture has been produced directly. The texture shown in Pl. 46, fig. 1, of Mem. Geol. Surv. Gt. Brit., 1907, N.W. Highlands of Scotland, is granulitic. The term granulitic should not be used to describe those textures of dolerites so described by Judd (*Q.J.G.S.*, 1886, vol. 42, pp. 68, 76 and pl. 5). For such textures granulitic should be replaced by intergranular (Evans).

KENYTE is retained for rocks practically identical with the kenytes of Mt. Kenya described by Gregory, 1900.

LAMPROPHYRE is to be retained in its present generally accepted sense to cover the "Lamprophyrische Ganggesteine" of Rosenbusch, 1910, the sense employed by Harker, Petrology for Students, 1919.

LEUCITE-PHONOLITE is to be used in the

sense adopted by Zirkel (1893) for a phonolite containing leucite in addition to nepheline and alkali-felspar.

LEUCITE-TRACHYTE is to be used in the sense of vom Rath (1867), as adopted by Zirkel (1893) and by Washington (1897); that is, a volcanic rock containing leucite in addition to the constituents of trachyte, and consisting, therefore, essentially of alkali-felspar and leucite, with relatively small amounts of ferromagnesian minerals, nepheline being absent or present as a minor accessory.

LEUCO- should not be used as a prefix indicating the presence of leucite, for instance, in leucotephrite.

META-, if used as a prefix, is understood to imply alteration of the original rock-type to the name of which it is prefixed.

MICA-SYENITE is retained in the sense of a syenite with dominant mica.

MINETTE is retained in use for the igneous rocks at present so named.

MONZONITE should be restricted to rocks of the type occurring in the Monzoni district, Tyrol, typically augite-bearing and containing a noteworthy amount of basic plagioclase in addition to orthoclase. The term "monzonite series" may be used to comprehend related rocks whether more basic or more acid than monzonite itself.

NEPHELINITE, LEUCITITE, and TEPHRITE are to be retained in use in the sense at present adopted by British authors. They do not contain olivine as an essential constituent, but may contain it as an accessory. The names NEPHELINE-BASALT, LEUCITE-BASALT, and BASANITE, are used so frequently that the committee does not feel able to recommend their disuse, but it would prefer to see these terms replaced by "olivine-nephelinite," "olivine-leucitite," and "olivine-tephrite."

OBSIDIAN. Glassy volcanic rocks of acid or intermediate composition, to be distinguished when evidence of composition is available, as rhyolite-obsidian, trachyte-obsidian, phonolite-obsidian, dacite-obsidian, andesite-obsidian.

ORTHO-. The use of this prefix as an abbreviation for orthoclase or to signify that a rock is rich in that mineral is not recommended. It is retained as a prefix to the name of a metamorphic rock to indicate igneous origin.

PANTELLERITE is allowable for rocks practically identical with those of the type locality, but preferably should be replaced by soda-rhyolite [or soda-trachyte] (Pantellaria type).

PARA- is retained as a prefix to the name of a metamorphic rock to indicate sedimentary origin. The significations given to this prefix by Loewinson-Lessing (1905), and by Lacroix (1920), are not adopted.

PERIDOTITE. Holocrystalline igneous rocks of ultrabasic composition, rich in olivine, and free from felspar or containing it only as an accessory constituent. Certain olivine-rich rocks which have been described as "hornblende-picrites" should be included. Varieties should be described by prefixing the name of the mineral characterizing them. The names "dunite" and "lherzolite," being well established and clearly understood, may be retained.

PICRITE should be restricted to rocks of the type locality of Söhle, Moravia, as described by Tschermak (1866), and to those closely similar rocks associated with teschenites and theralites in other regions.

PITCHSTONE. Glassy rocks of similar range in composition to obsidian, but characterized externally by pitchy lustre, splintery or hackly fracture, and a relatively high content of water. They are usually hypabyssal.

PORPHYRITIC TEXTURE. The definition given by Teall in 1888 (*British Petrography*, p. 51) is adopted, namely: "When . . . certain constituents occur as large or more or less perfect crystals in a matrix of finer grain, the rock is said to be porphyritic."

PORPHYRY and PORPHYRITE. Hypabyssal rocks of acid or intermediate composition with one or more porphyritic constituents in a crystalline (including cryptocrystalline) groundmass. Such rocks with dominant alkali-felspar are termed "porphyry," as distinct from those with dominant soda-lime-felspar, which are termed "porphyrite." These terms should be qualified by prefixing the name of the mineral or minerals which occur as porphyritic constituents. The name "granite-porphyry" is ambiguous, and should not be used.

PYROXENITE. Those members of the perknite group with dominant pyroxene; that is, in the original sense of Coquand, and the sense in which it is employed by Harker and Hatch. Perknite, introduced by Turner (1901), and adopted by Hatch (Igneous Rocks, 1914), may be usefully employed as a group name for holocrystalline igneous rocks composed of various combinations of hornblende, augite, and rhombic pyroxenes, together with accessory biotite, olivine and iron-ores. They occur as deep-seated masses or as dykes.

SHONKINITE is retained in the sense of the original definition of Weed and Pirsson (1895), and the more detailed definition of Pirsson (1900). The rock of Square Butte, Highwood Mountains, Montana, described by Weed and

Pirsson and analysed by the latter, is an olivine-bearing shonkinite with accessory nepheline, sodalite, etc., in small quantities. If, in certain varieties of shonkinite, leucite or nepheline become notable constituents, such rocks should be distinguished as "leucite-shonkinite" or "nephelene-shonkinite."

THERALITE is retained for nephelene-gabbros, the rock adopted as the type being the theralite of Duppau, Bohemia, and not the rock originally described as theralite from Gordon's Butte, Crazy Mountains, Montana.

TONALITE should be replaced by quartz-diorite (Tonale type).

TRACHYBASALT is adopted to replace the term "trachydolerite" as used by Washington in 1897, that is, for intermediate potash-rich rocks containing basic plagioclase together with orthoclase. The use of the term trachybasalt in the sense of Boricky (1873) having been long discontinued, no confusion should arise from its re-introduction in a new and self-explanatory sense.

TRACHYTE. Tyrrell's proposal to use "trachyte," "bostonite," and "keratophyre," with textural significations for rocks which have essentially the same chemical and mineral compositions, regardless of whether they are of extrusive or intrusive origin, is not adopted.

Obsolete Words.

The following terms have been used in more than one sense, and are either obsolete or unnecessary, so it is recommended that their further use as petrological terms should be avoided: Adamellite, Anamesite, Aphanite, Bauxitite, Binary granite, Cipolin, Cornubianite, Diabase, Diallagite, Domite, Dunstone, Euphotide, Eurite, Felspar-rock, Granitite, Hyperite, Hypersthenite, Leptynolite, Leucitophyre, Leucotephrite, Melaphyre, Nepheline-dolerite, Oligoclasite, Palæopicrite, Syenitite, Trachydolerite, Wehrlite.

Synonyms.

The following is a list of synonyms, with the term printed in small capitals which is recommended in preference to the alternative term, or terms, which are printed in ordinary type.

ACCIDENTAL INCLUSION (Harker, 1900): exogenous enclosure.

ACID: persilicic.

ALLOTRIOMORPHIC (Rosenbusch, 1897): xenomorphic; anhedral.

ARENACEOUS: psammitic.

ARGILLACEOUS: pelitic; lutaceous.

BASIC: subsilicic.

COGNATE INCLUSION (Harker, 1900): autolith; endogenous enclosure.

CONTACT METAMORPHISM: exomorphism.

CORONA: REACTION RIM; kelyphitic rim. If the corona can be shown to be due to alteration or modification of the nucleus the term "reaction rim" is preferred.

GLASSY: Hyalo-; vitro-.

HEMICRYSTALLINE: merocrystalline; semicrystalline.

HYPIDIOMORPHIC: hypautomorphic; subhedral.

IDIOMORPHIC: automorphic; euhedral.

INCLUSION (in rock): enclosure; included nodule.

INTERMEDIATE (silica content): mediosilicic.

MULLION STRUCTURE (Kinahan, 1891): rodding structure.

ORBICULAR STRUCTURE (Delesse, 1849): spheroidal structure.

PILLOW STRUCTURE: ellipsoidal structure.

PSEPHITIC: rudaceous.

LETTERS TO THE EDITOR

The Greenside Mine.

The Editor:

Sir—I am afraid your correspondent "Interested" is not so conversant with the financial part of Greenside mine as he would appear to be. A profit of 14% per annum is a good thing, but I am sure if it was realized here, it was prior to the last 60 years.

I am puzzled to know what paid-up capital "Interested" based his calculations on, and how obtained, as the conversion of the partnership company to limited liability only took place in 1890. Possibly it was over-capitalized then, but as there was no public issue this mattered little to those interested.

From 1890 to 1919 the mine was under my management, and during those years we had good and bad times, and made profits with pig lead at a very low figure. But unfortunately during the whole of these 29 years, royalties, rates, and taxes practically absorbed *one half* of the gross profits. Greenside has been a wonderful mine, although a low-grade proposition. By adopting up-to-date appliances (for instance, it was the first metalliferous mine in this country to adopt electricity), it managed to exist with pig lead at £9. 6s. per ton, and silver at 1s. 10d. per oz. There are still chances of success in this old mine with fair and reasonable royalties. The owners are now prepared to modify their terms, but, unfortunately, not be-

fore the company decided on voluntary liquidation.

WM. H. BORLASE,
Liquidator and late Manager.
Greenside, Cumberland, March 24.

Wave-Transmission Rock-Drill.

The Editor:

Sir—I have read the articles in your issues of February and March on Wave-Power Transmission. I disagree altogether with Mr. Risdon's opinion as to the suitability of this system of power-transmission for rock-drilling, as I hold it to be hopelessly inefficient when judged from the power expended *on the surface*, and the number of feet actually bored per unit of time in the rock face.

Much has been written and published in recent periodicals and daily papers as to the supposed advantages to be gained by the substitution of wave-power for compressed air, but I hold that the comparisons have been most unfair to the compressed-air system. In all cases that I have noticed it seems to be assumed that electric power is to be used for driving both the wave generator and the compressor, and we are then informed that greater drilling speeds can be obtained per horse-power expended by the adoption of the wave-power system. I disagree with this representation of the case in all particulars.

If the two systems are to be compared on a fair basis, we ought to assume that one system or the other is to be installed on a mine which is about to be equipped, and due regard should be paid to the conditions which will exist when the mining operations are being carried on at a moderate depth; for the sake of argument let us say 1,000 ft., and, as I will show later on, the balance will turn more and more decidedly in favour of the compressed-air machines as greater depths are reached.

In the compressed-air system, boilers and steam-driven air-compressors will have to be erected, the compressed air being led directly to the air-drills at the working faces. If the wave-power transmission is to be installed, the steam will have to be taken to suitable high-speed engines coupled to dynamos, the high-voltage current conducted down the shaft to the chamber or chambers which have been provided for the reception of the wave generators and the requisite electric switch-gear, transformers, and motor or motors. The power pipe-line will start in these chambers and be led to the various rock-drills.

Obviously the compressed-air system is by far the simpler, being merely boilers, steam-driven air-compressor, pipe-line, and rock-drills. In the case of the wave-power system we have: boilers, high-speed steam engine, dynamo, electric cables, step-down transformers, electric motors, wave generators, pipe-line, rock-drills.

In both cases the transformation of energy and its transmission will entail unavoidable losses. Let us see what they amount to in each case, assuming that 1,000 i.h.p. is being generated on the surface. As to the compressed-air system, any good manufacturer of air-compressors will be quite prepared to guarantee 5·8 cubic feet of free air compressed to 80 lb. gauge pressure per minute per i.h.p. in the steam engine. With a suitable sized air pipe-line, the loss of pressure at a distance of 1,000 ft. will certainly not amount to more than 2 lb. per square inch, and even this amount of energy is not entirely wasted, as the volume of the air is increased proportionately with the loss of pressure. For the moment, however, we may assume that the loss is a complete loss as it simplifies the comparisons, and that we now have 5,800 cubic feet (measured as free air) at 78 lb. per sq. in. available for operating the rock-drills.

The wave-power drill manufacturers seem to have adopted for purposes of comparisons with their own machines a cradle type of air-driven rock-drill of a well-known make, and for the sake of our example we will also take a machine of this type, though we should note in passing that there are other and more efficient types of rock-drills available. The cradle type of air rock-drill mentioned above requires not more than 100 cubic feet of free air per minute (measured as free air), and many rock-drill manufacturers will be very pleased to guarantee a considerably smaller consumption. This machine will easily bore, in granite, at the rate of not less than 8 in. per minute with a bit of 1⅝ in. diameter, so that with 5,800 cubic feet (measured as free air) available, we have a boring capacity of $58 \times 8 = 464$ inches per minute.

Turning now to the wave-power transmission plant, with a 1,000 i.h.p. in the cylinders of the steam engine we shall have a brake h.p. available of about 900; this will give us at the terminals of the dynamo, assuming an efficiency of 93%, which is quite good, the equivalent of 837 h.p. The cables down the shaft will entail a further loss of 5%, and the step-down transformers will account for yet another 2% of the balance, leaving the equivalent of 779·25 h.p. available at the terminals of the electric motors which are coupled to the wave-generators.

When I saw the wave-power drill at work,

I noted that the wave generator required 12 h.p. in the motor to operate one drill, and I was informed that the drill was capable of boring in granite with a $1\frac{5}{8}$ in. diameter bit at the rate of 5 in. per minute. My own observations do not bear out the latter statement, and I am inclined to believe that the actual boring speed would not exceed one half of the amount given above. But assuming for the sake of argument that the figures are correct as stated, and that 12 h.p. delivered to the terminals of the electric motor is equivalent to a drilling speed of 5 in. per minute with a bit of the size taken, we have a total drilling capacity for 1,000 i.h.p. on the surface of 779·2 multiplied by 5 divided by 12 = 324·6 in. per minute.

Stated in another way, the drilling capacities of the two systems per minute per i.h.p. on the surface are: compressed-air system, 464 in.; wave-power drill, 324 in.

From the above considerations I hold that the wave-power system is not a serious competitor to the pneumatic, even if no other advantages accrued from the use of compressed air as a means of operating rock-drills, and when Mr. Risdon states, as he does toward the end of his article in the March issue, that manufacturers of compressed-air plant are living in anxious times from the fear of the proposed new system of running rock-drills, he is very far from the truth. I can assure him that manufacturers of compressed-air rock-drills are very anxious indeed to cut out the talk and get down to actualities, and that the sooner a reasonable-sized installation of wave-power rock-drills is in actual use for serious mining work the better they will be pleased, as they are quite convinced that its replacement by the much more efficient and simple pneumatic system is only a question of a very short time indeed.

With the wave-power rock-drill some system of ventilation of the working faces, especially in development work where the ends may be far from the main ventilation currents, will be imperative, and will add much to the overall cost of breaking the ground; with pneumatic drills, on the other hand, this is provided for by the exhaust, and the energy which was counted as lost in the air-compressor at the surface, due to the heat of compression absorbing power, now appears as refrigeration in the working places, and how important this is will be readily admitted by all actually engaged in underground drilling.

To sum up, I consider the main advantages of the pneumatic system can be placed under the following heads: Simpler installation; faster boring speeds per i.h.p. at the surface; more flexible system; ventilation of the working places; refrigeration of the working places; helps to dry the air in the working places; dry drilling can be done when required.

I assume that dry drilling is quite impossible with the wave-motion drill, and it is well known that certain deep and hot mines will not consider wet drilling for a single moment, as the humidity of the atmosphere in the working places is even now almost intolerable.

There are many other advantages to be obtained from the installation of the pneumatic system, but as they are well known to mining engineers it is needless to occupy any more of your valuable space, on which I fear I have already unduly encroached.

R. de H. St. Stephens.

Camborne, April 10.

BOOK REVIEWS

This World of Ours. By J. H. Curle. Cloth, octavo, 315 pages. Price 7s. 6d. net. London: Methuen & Co., Ltd.

I have twice read most of "This World of Ours," and many parts I have even again re-read, for I have been greatly interested. Those who imagine the opening sentence, so reminiscent of the old admonition, "Cheer up! You'll be a long time dead!" to be the forerunner of a volume of sombre colour will be agreeably disappointed, for many bright pictures will be found thereafter.

My initial attempt at reading the book was not a success, for I soon became entangled in its peculiarities of punctuation; and my preconceived notions of good writing were upset by sentences and phrases terminated by prepositions. These, coming from the pen of an experienced writer like Mr. Curle, caused me to seek for some studied effect; and I struggled manfully on, often losing the gist of the narrative in attempting to find the hidden rhythm or other intention of the author. I progressed for several pages, stumbling over such difficulties as the following sentence: "For eight hours each day, or, every third week, each night, I had the amalgam plates in trust; . . .", and finally coming to grief at the bottom of page 22 in the full belief that four horses had been sitting beside Mr. Curle in a Cape cart and that Johann Rissik held the reins and H. B. Marshall. I laid the book aside, not knowing whether I had been listening to a story told by a man with an impediment in his speech, or whether, sitting in one of a string of L.C.C. tramcars during the congested hours of traffic, I had been reading and the sentences had been punctuated

for me by frequent and sudden applications of the brake. Having fully convinced myself that the subtlety of the sentence-maker was beyond my ken, I retraced my steps, started again at the beginning and, mentally supplying an occasional semi-colon and leaving out most of the commas, I soon became enmeshed in an interest of travel that seldom flagged.

Perhaps the parts of Mr. Curle's book which least appeal to one are those in which he attacks the Christian church; and it is to be feared that much will be found in this direction which will greatly detract from the pleasure of those readers who are sensitive regarding such matters. Indeed, it is difficult to see why, because crab eats crab, and unhygienic savages at Nyanza die of sleeping sickness, Mr. Curle should revile curates and clergy, any more than one should feel moved to do so because at Verespatak the life of a lamb was sacrificed in order that Mr. Curle might fill himself to repletion and, in an ecstasy of surfeit and emotion, endeavour to embrace a fat old Hungarian girl. And oh! the conceit of the Scot who says that, he being an agnostic, all thinkers must also become agnostics!

The first chapter of the book touches lightly on the youthful days of the author, his first trip to Australia, his return via Colombo, a visit to Africa, and his subsequent University life. The next chapter sees him returned to Africa and eventually becoming managing director of an East Rand coal mine. During the 6½ years spent on the Rand the author visits Rhodesia, Kimberley, and other places. We should have liked from him, as a sordid setting for the diamond, one of his pen pictures of Kimberley, depicting its hot, dusty, depressing, and crooked streets and uninteresting surroundings. Instead, we have to be content with the usual banal remarks about the vanity of woman and the vice of man, and with the oft-repeated reference to buckets of diamonds which nearly every writer on Kimberley seems compelled to make.

Chapter three sees the author standing in reverie near the old fish-market of Cape Town on the eve of his departure from Africa; and it is in this chapter that the true writing of the book begins. In it we get a fine retrospect, a fine description of men, beasts, and places, and, by the way, some very good tips for intending sportsmen. Standing there in the still twilight in sleepy, pretty little Cape Town—so often swept by blusterous gales—the author puts into words what many a traveller must have felt: the vastness of the African continent. It is strange that this immensity of Africa should be felt at Cape Town more than at Durban, East London, or Port Elizabeth, which are also its portals. I have felt the immensity of the Asian continent more when standing under the shadow of the peaks of Hong Kong than in either Shanghai, Saigon, or Singapore. Is it that the nearby mountains or hills lend themselves to such reveries? If so, we have to thank Table Mountain for a fine descriptive chapter from Mr. Curle.

The author next takes us to India, Australia, South America, Siberia, the Gold Coast, Western North-America, and Klondyke, a very long distance to travel in 20 pages. Nevertheless, he finds space to give us a stirring description of an accident which befell his sleigh on the false ice of the Amur at 20° F. below zero. The staccato system of punctuation here suits the situation; the story has atmosphere; we are actually with the men and horses in their struggles; and we feel greatly relieved when all ends well.

Pleasure travels in Spain and the north of Africa give history as well as happy descriptions of the places visited; and so mild has become the language of this vigorous writer that he calls the odours of Harar nothing stronger than a "shocking stench."

To attempt to follow the writer through all his travels would be futile; but we are commercially interested in his Lake Guatavita, two days' ride from Bogota in South America, because we have heard recently of a resuscitated project to remove the mud from this lake and obtain the legendary jewels.

During his peregrinations round the Caribbean Sea, the author tells an amusing story against himself which threatened to become serious, while attempting to land at Aux Cayes. He later gives us a graphic description of a bull-fight in Barcelona which, like the story of the sleigh accident, is much assisted by the staccato effect of the punctuation. From journeys up and down Europe the itinerary changes to the country between Archangel and Astrachan. Among other places, Nizhni was visited and the fair found to have been destroyed, so people said, by the advent of the Siberian railway; but, as far as my recollection goes, history relates that the real splendour of Nizhni fair departed, and never returned, after the slaughter of the populace by Ivan the Terrible.

Astrachan, the great centre for caviare—the roe of the sturgeon—is visited; and the author's remarks thereon remind one of the days before the war, when caviare was displayed for sale in large tubs placed outside the fish shops in large Russian cities at ridiculously low prices.

One gets a general impression from Mr. Curle's book that he considers the women of most countries much superior to the men. Page 209 gives such an example. Here we have a song in favour of the Slav woman, to which it is doubtful whether all who have dwelt in Russia will subscribe; but, no doubt, all will heartily agree with the sentiments with which the twelfth chapter is concluded.

The descriptions of the Holy Land and of the dwellers therein are full of interest; and one cannot but be impressed by the author's oft-expressed high opinion of the Jew of to-day. An interesting interlude is a thumb-nail sketch of American tourists in the Church of the Nativity. The sketch is so thoroughly typical that one feels it to be true to the life.

The traveller then takes us through India and the Far East; but were he to revisit the latter, he would find matters in Singapore far different from those depicted on page 269. The local D.O.R.A. has cleared out all the white prostitutes from Malay Street; and the glory of Cossack Street has departed. The Japanese higher classes have also formed a strong society, backed by much money and with widely distributed branches, for inducing their frailer women-folk to depart from foreign shores and compete with their sisters in the overcrowded land of their nativity. All British dwellers in the Far East will heartily endorse the author's praise of the Chinese and his criticism of the Japanese. The latter, taking advantage of our war preoccupation, stepped into the Malay Peninsula and bought houses and rubber lands to such an extent that it became necessary to pass an enactment practically preventing the sale of real estate. So far, fortunately, he has been unable to obtain a footing in Colombo.

All will not agree with the comparison between Javanese and Malay women. Generally speaking, a loose woman of either race is very, very loose; and, not taking much account of venereal disease, is most often a being best fitted for the lazarette.

The journey next continues to the South Seas, the author taking his final leave of us at a Presbyterian mission station in the New Hebrides; those of us who have done our modicum of world's travel envy him his excellent memory and his facile pen.

So ends "This World of Ours." A little boastful, perhaps; perhaps at times a little arrogant; but greatly interesting as a book of travel, and useful to many as a book of reference.

V. F. Stanley Low.

Coal Washing. By Ernst Prochaska, M.E. Cloth, octavo, 382 pages, illustrated. Price 24s. net. New York and London: The McGraw-Hill Book Company.

The number of books devoted entirely to the cleaning of coal is so limited that the publication of a new work on the subject is of distinct importance, especially when it is, upon the whole, well done. Needless to say, it is written by an American, and is restricted to American practice, but it is idle to deny that it would have been better had its Americanism not been so pronounced. The author appears to have very little knowledge either of British literature or of British practice in his subject, and it is somewhat amusing to find him writing of appliances as used "in Europe," without any appreciation of the very wide difference that exists between British and Continental coal-washing methods. On the other hand there is much that we on this side can learn from American practice as described by Mr. Prochaska, and attention may be directed particularly to his insistence upon the use of automatic feeding devices for regulating the supply of coal to the washers, and of automatic sampling appliances for taking regular samples of the various products, two items in which we are decidedly deficient in this country.

The book is divided into two parts, the first dealing with the history and development of coal washing, and the second with details of the various methods and appliances as they are used to-day. In the former his imperfect knowledge of the British literature of the subject is a drawback; for example, he does not seem to know that the first jig with fixed sieve was devised by a Cornishman, Captain Petherick, about the year 1830. Again, his statement that the jig "has finally attained its present position as the only successful apparatus for washing coal" is far too sweeping; in this country we have numbers of other appliances doing quite satisfactory work. The author entirely ignores the shaking table as used for washing nut coal, such as the Campbell and Craig tables, and more recently the Notanos washer of Messrs. Head, Wrightson & Co., Ltd., all of which are well known in this country; on the other hand we have much to learn in the use of tables of Wilfley type, which are being used in America for washing fine coal, and to which the author devotes a very instructive chapter.

There are also valuable chapters dealing with the economic aspect of the question, and these demonstrate that the author really knows better than his opening chapter would lead one

to suppose, as he concludes this with a "maxim" to the effect that the object of the preparation of coal is to "secure a maximum price per ton of output." Needless to say, this is quite false; the real object is to secure the maximum *profit* per ton of mine output, and no one knows this better than the author himself.

HENRY LOUIS.

Political and Commercial Geology. Edited by J. E. SPURR. Cloth, octavo, 570 pages, illustrated. Price 30s. New York and London: McGraw-Hill Company.

This book deals with the raw materials of the metal industry and commerce, principally, if not wholly, with those which during the war came under Government control; it concerns itself with their sources, their markets, and their places of consumption.

Each raw material is handled separately by a specialist, such specialist being generally the one into whose hands, under the Bureau of Mines in the United States, watch over the particular material was entrusted for war purposes. The whole series is shortly introduced by J. E. Spurr—now editor of the *Engineering and Mining Journal* of New York, but during the war Chief of the Mineral Boards—who at the end more comprehensively summarizes the position disclosed.

The attention each material receives begins with its uses, and then proceeds with the practice by which it is made marketable; the chances and effects of possible changes in practice; the part, essential or luxurious, replaceable or irreplaceable, the particular material plays; the respective geographical and geological distributions; the territorial productions; and the parts taken by the several nations in the final control. All these aspects are under separate headings, the salient features being assembled in a useful summary.

Thus are treated in succession: petroleum; coal; iron; manganese; chromium; nickel; tungsten; vanadium; antimony; molybdenum; radium and uranium; zirconium, monazite, thorium, and mesothorium; copper; lead; zinc; tin; mercury; bauxite and aluminium; emery and corundum; magnesite; graphite; asbestos; phosphate; potash; nitrogen; pyrite and sulphur; gold; silver; and platinum. Assembling these under a broad classification, fuels occupy about 50 pages; iron and steel 40 pages; the ferro-alloy metals 90 pages; the rare metals and earths 30 pages; the major base metals 110 pages; the minor metals 60 pages; and the precious metals 60 pages. To these, in conclusion, are added about 25 pages wherein the editor puts and answers the question "Who owns the earth?"

The declared purpose of this series is to shed light upon the vast political significance of commercial control of mineral wealth. It abundantly succeeds. The actual fact of this importance was painfully realized during the war, but the forces at work, unfelt though compelling, were not so apparent. They are here traced and recorded. In some commodities, coal and iron for instance, territorial or national control is adequate; the material generally need not be taken away to be made marketable. In others, zinc and nickel for instance, control is effected largely through smelters and refineries and through selling contracts, the materials being of sufficient value to bear the burden of freights. Control with these is possible without mine-ownership, and may become foreign, the raw materials passing to other countries to be converted.

War showed Germany largely controlling the metal industries, and the Allies in consequence with an incomplete equipment for the test of war. It showed, moreover, that though a foreign interest could by war be eliminated, it left the national industry with much to improvise. In laying these things bare, the book pictures the movements of ores to works, and of metals to and from their markets, a broad and interesting view. It casts glimpses into the future, as when it envisages the ultimate transference of the balance of power to the Pacific by reason of the immense coal resources of China. These aspects are of particular importance to the political economist, but at the same time they cannot fail to interest the mining engineer. In addition, for the latter the details of occurrence, use, practice, etc., will be found neatly yet comprehensively summarized.

With many contributors styles differ, but the writing is often excellent, clear, informative, and precise. Sometimes it is a little biased, as when it imputes an aggressive nationalistic policy to Britain; while throughout it shows concern for the still stronger nationalism of Japan; Germany it regards as punished for pressing nationalism too far. The whole book must, however, be regarded as a very valuable contribution to industrial literature, and one deserving of wide circulation. The net proceeds of its sale will be used to further the purpose to which it is itself devoted.

The United States and the British Empire cannot but feel flattered by the place they take in the world's mineral industry, these two States largely owning that industry.

S. J. TRUSCOTT.

Lubricating and Allied Oils. By ELLIOTT A. EVANS, F.C.S., A.M.I.P.T. Cloth, octavo, 144 pages, illustrated. Price 9s. 6d. net. London: Chapman & Hall, Ltd., 11, Henrietta Street, W.C.2.

The "Directly-Useful Technical Series" of books published by Messrs. Chapman & Hall, Ltd., has recently been added to by the production of the present little volume on lubricants, which should prove of some practical use to oil technologists in the course of their chemical work in the laboratory, and to engineers and others who may constantly have to investigate the properties of oils suitable to their several requirements. The book, however, is remarkable for the unfortunate admixture of relevant and irrelevant matter (the "directly useful and the indirectly useful"), and in view of its essentially practical purport, we are frankly surprised at some of the chapters and paragraphs which the author has seen fit to include in the text.

The direct utility of the volume, in our opinion, centres chiefly in Chapters 4, 5, and 6, which discuss the physical and chemical tests usually applied to lubricating and allied oils; this section is undoubtedly good because, although largely descriptive of well-known standard methods, the author has supplemented these with many pertinent hints on their manipulation, drawn from his own practical experience. In this connection we would mention particularly his remarks on flash-point determination, in which he summarizes the commoner sources of error possible under varying conditions of operation, and he adduces some most interesting results of experiments made personally showing, among other things, how the flash-point varies with the rate of heating and with the time intervals taken for inserting the flame. Viscosity also receives excellent treatment, and the Redwood, Engler, and Saybolt viscometers are fully discussed, while the conversion tables included for these types are most useful as a means of rapid comparison between the conventional expressions used in each case. The chemical tests are lucidly described and include all those determinations usually made for ordinary purposes; in the paragraphs dealing with sulphur estimation no mention is made of Jackson and Richardson's modified form of apparatus for the lamp method, described in a paper read before the Institution of Petroleum Technologists in November last, which would seem to offer decided advantages over the better known Esling apparatus. (See *Journal* of Inst. Pet. Tech., January, 1921, p. 26.) It may possibly have been too late to include this in the present volume, but Mr. Evans will doubtless discuss this modification in the next edition of his book, and the possibilities of its use with lubricants suitably diluted.

The other chapters are of much less merit, mainly on account of their extreme brevity or doubtful relevance; they include paragraphs on the oxidation of petroleum as productive of asphalt, on oleography, on oil refining, and on selection of lubricants for specific purposes. We should have much preferred expansion under these headings at the expense of the chapters on the history of petroleum (entirely out of place in a work of this description), on the occurrence of fatty oils (too short to be of any great value), and on oils employed, the last a most unfortunate inclusion in its present form, since it savours strongly of advertisement, which we deplore in any technical or scientific work. While venturing to make the above suggestions, in compliance with the author's request expressed at the close of his preface, we most strongly urge the deletion of pages 112, 113, and 114, together with the fourth paragraph on page 115, in future editions of the book.

H. B. MILNER.

The Technical Examination of Crude Petroleum, Petroleum Products, and Natural Gas. By W. A. HAMOR, M.A., and F. W. PADGETT, M.S. Cloth, octavo, 600 pages, illustrated. Price 36s. net. New York and London: McGraw-Hill Book Company.

The well-known text-book on the American Petroleum Industry by Messrs. Bacon and Hamor, finds a valuable and practical supplement in the present work by Messrs. Hamor and Padgett, in which chapters 4, 11, 12, and 17 of the former volume are here elaborated into eight, with two additional sections and an appendix of 272 pages, the latter itself constituting an oil chemist's *vade mecum* of exceptional practical value.

This book deals principally with the technical examination of crude petroleum, petroleum naphtha products, illuminating and lubricating oils, greases, bituminous road material, natural gas, and the distillation of oil-shale, while in view of the ever-increasing importance of benzol as a motor fuel, a chapter on benzol-recovery plant operation has been contributed by Mr. F. W. Sperrs, Jr., of the Mellon Institute of Industrial Research, University of Pittsburgh. Great care has been taken in describing the various standard methods adopted in

each case, and in many instances alternative methods are discussed, the outcome of recent research, thus enhancing the value of the work and bringing it entirely up to date.

The sections of particular merit are undoubtedly those treating of the examination of bituminous road materials and the examination of natural gas. In the former case the several physical and chemical tests applied to bituminous materials are described in systematic detail, and the methods employed are essentially those which have been thoroughly worked out in the laboratories of the Office of Public Roads, United States Department of Agriculture. The examination of natural gas comprises sampling, determination of density, heating value, analysis, estimation of amount of gasoline content, evaluation of carbon black, and measurement of gas (calibration of meters, etc.). In this country there is comparatively little opportunity for conducting investigations of this character, and consequently our knowledge of the latest methods is usually restricted, except in special circumstances; we therefore not only welcome this comprehensive summary of natural gas examination, but we are strongly tempted to obtain gas samples from Heathfield, Sussex, if only to test the efficiency of the method and apparatus for analysis described and figured on page 257, the outcome of some excellent work by Burrell and others at the United States Bureau of Mines. (See also Bureau of Mines Technical Paper 87).

Possibly a mild criticism of the book may be levelled at the totally inadequate treatment of oil-shale evaluation, which had far better have been omitted as inapposite to the volume than included in its present form. The whole question of retorting oil-shale is so controversial and our knowledge of commercially efficient methods so ramified, that the barest outline of the subject is more misleading than useful, particularly in the absence of any generally recognized standard method of distillation; we welcome in this connection, however, the description of Mr. C. L. Jones' method and apparatus, devised at the Mellon Institute, which certainly seems to obviate some of the more usual difficulties encountered in laboratory shale retorting, such as variations of temperature, uniform heating, and the prevention of condensation of volatile matter within the retort.

We certainly do not ever remember having read an appendix to a technical treatise of such great length and utility as that incorporated in the present volume; printed in smaller type and crowded with tables of constants, viscosity curves, additional methods of examination of oils and bituminous material, diagrams and illustrations of further apparatus, it constitutes the requisite amount of elasticity of treatment of the subject matter commensurate with the scope of the work. As a matter of convenience, we would suggest the inclusion in future editions of a contents page prefatory to this section, in view of its magnitude and importance.

The authors challenge us to critical analysis of their index by the following quotation from Horace Binney, printed at the head of page 573, and to which we venture to draw the attention of many scientific writers of to-day: "The best book in the world would owe the most to a good index, and the worst book, if it had but a single good thought in it, might be kept alive by it." We congratulate the authors not only on the excellence of their index, but also on the production of a work of exceptional merit and utility, a most valuable addition to existing literature on the technical analysis of petroleum and petroleum products.

H. B. MILNER.

A Text-Book of Geology. Part 1. Physical Geology. By LOUIS V. PIRSSON. Second edition, revised. Cloth, octavo, 970 pages, with maps and illustrations. Price 17s. 6d. New York: John Wiley & Sons; London: Chapman & Hall, Ltd.

The appearance of a revised edition of this well known text-book within five years of the first issue speaks well both for the popularity of the work and for the intention of the author to keep his text-book up to date. The author deals with his subject in the usual order, discussing first the action of the various destructive and constructive agents. He is careful to impress on the student that the chemical action of air is dependent on the presence of water, which is important, as dry air has practically no chemical action on the rocks. The chapter on the geological work of organic life gives a treatment of the subject which is much more detailed than in many of the geological textbooks. It would perhaps have been more logical to deal with earth movement before discussing vulcanicity, but this is a point of minor importance.

Section 2 deals with structural geology, including the structure of the earth, composition and tectonics of sedimentary, igneous, and metamorphic rocks, fractures and faults, mountain building, and ore deposits. The plan of dealing with tectonics under the various rock types has much to be said in its favour, but the classification of the igneous rocks includes the term "felsite" which has too many applications to

be satisfactory, and syenites are described at one place as being devoid of quartz and at another as containing quartz in small proportions. The chapters on faults and mountain building are excellent.

The growing importance of geology as an economic science is indicated by the presence of a chapter on ore deposits. One could wish that the author had referred to economic deposits other than those of the metals, and the statement on page 411 that "metallic copper and silver may be also produced by the oxidation and alteration" needs revision.

There is an appendix dealing with the physical and chemical properties of the more important rock-forming minerals, and a selection of some ore-minerals, which does not, however, include any minerals of tin or tungsten.

The book is well illustrated by photographs and diagrams, and it is of interest to note that the photographs are by no means restricted to American examples, as is often the case in American publications. The print is excellent and the index appears to be full and complete. At the end of the book is a geological map of North America of sufficiently large scale to be really useful. The text-book can be thoroughly recommended to the geological student.

E. H. Davison.

☛ Copies of the books, etc., mentioned under the heading "Book Reviews" can be obtained through the Technical Bookshop of *The Mining Magazine*, 724, Salisbury House, London Wall, London, E.C.2.

NEWS LETTERS.

MELBOURNE.

The Coal Output.—The decrease in the coal output of Australia is causing much anxiety. In 1913, 12,500,000 tons were produced, and although figures are not yet available for the year just closed, it is not expected that the total output will reach 9,000,000 tons. In the same period the number of men engaged in the industry has increased by 1,267. In 1913 the production of coal per man was 553 tons, in 1919 it was 540 tons, and for 1920 it is expected to be about 490 tons. Mine-owners generally are alarmed at the continued reduction of output, and there is a feeling that matters are rapidly approaching a crisis. Although at present the strike of the marine stewards and the consequent hold-up of inter-state shipping have slightly eased the position in regard to local supplies, there is still a serious shortage of coal, and at Newcastle the delay to vessels awaiting shipment is as bad as ever.

This great fall in output, owners believe, is due to the deliberate policy of a section of the miners. Within the years covered by the figures quoted, the eight-hour bank-to-bank system came into force, but any reduction in the output through this shortening of hours should, they contend, be more than made up by the increased number of men employed in the industry, and the greater efficiency of the modern mine equipment which has since that time been installed. The proprietors believe that the extremists among the members of the Colliery Employees' Federation are out to make private ownership of coal mines an impossibility, and that one of the methods they have adopted to achieve this end is the go-slow policy, with its consequent reduction of production. At present the miners are working the eight-hour bank-to-bank system, which includes the time taken in descending the pit and arriving at the coal face, the return to the surface, and the dinner hour. This means that actually the miner works much less than eight hours per day. In some pits the working hours are a little more, but generally the owners state that the period of labour averages six hours. The Australian output to-day is about six million tons a year below present market requirements, and about one million tons below what is required for Australasian consumption. The miners, since 1913, in addition to their claims for eight hours bank to bank, have had granted to them increases in wages averaging 8s. 6d. per day. They are, however, dissatisfied with their conditions, and are now claiming, among other concessions, a six-hour day and a five-day week, the abolition of the contract system, and a minimum weekly wage. Of these claims the most important is that for the reduction of hours to six per day. As has already been stated, the coal production of Australia is below requirements and a further reduction equal to 25%, which is believed to be certain to follow the granting of a shorter working day, must inevitably affect the whole of the industrial life of Australia.

Production, as far as efficiency of machinery and general handling methods are concerned, has reached its greatest point, while the employment of additional men has already been under consideration and found impracticable. The demands for a six-hour day and a five-day week are put forward by the miners for health reasons. Coal mining they say is an unhealthy occupation, dangerous and arduous. In reply to this contention owners declare that the occupation is no longer an unhealthy one, and that the average coal miner is just as healthy

a person as any other in the community. The mines are well ventilated, the temperature even, and there is little dust. In New South Wales, they point out, the conditions are altogether different from those existing in other parts of the world. Here the thickness of the coal seam reaches to over thirty feet, and the mines are large and roomy. In England the miner has to work on a seam as thin as eighteen inches, and averaging about five feet thick. Again, in the local mines there is practically no dampness, while the dangers below are no greater than on the surface.

VICTORIAN MINING.—A review of the operations of the Victorian Mines Department during 1920, made by the Minister of Mines, shows that the Ministerial view of the prospects of mining during the current year is quite hopeful. The outlook for gold-mining is considered brighter for the new year. On the Bendigo field the results of recent surveys give further insight into the features of gold deposition, and an extensive memorandum, accompanied by a complete topographical and geological plan of an area of over 30 square miles, is being printed. This memorandum will serve as a guide to future prospecting. At Blakeville a survey of this one-time goldfield has been carried on, and it has reached the limits of the Blackwood field, where detail work will be continued in the new year. To prove the existence of a deep lead in the neighbourhood of Springdallah a drill was engaged for a time, and it located a narrow vein of wash. The Harrietville field is again attracting attention, and several good mines are in operation. At Daylesford the Ajax North mine is opening up large bodies of ore in new ground, and the prospects of adjacent mines are brighter. In the Wood's Point district surveys of several mines show improved prospects. The Rose of Denmark has found a new shoot of gold ore 625 ft. south of the shaft at a depth of 500 ft. below the adit level, with prospects of 650 ft. of backs on this formation. The A1, in addition to operating on ore of average value for the past ten years, is now developing lodes below the worked formations, and these are opening up satisfactorily in untried ground. The Morning Star, after five years' work, has discovered payable values at the 500 ft. and 600 ft. levels. This work was carried out chiefly by the guidance of the Geological Survey officers, and assisted financially by the Mining Development Act. The company is now resuming sinking operations to test the dyke at greater depth. The New Loch Fyne, at Matlock, operated on ore averaging over an ounce to the ton at a depth of 100 ft. below the adit level. This work was also carried out with the collaboration of the Survey and the company. Shortage of labour has handicapped the further development of this promising mine.

Dealing with the prospects of coal, the report says that plans of an area of about 10,000 ft. square at Morwell have been completed. Surveys in the vicinity of Traralgon, in co-operation with boring, have extended the brown coal-bearing areas, proving a maximum thickness in one bed of 650 ft. Two drills are now engaged in this locality. Plans embracing an area of 400 square miles have been completed. At Lal Lal boring is proceeding. On the Tyers river area boring is in progress to delimit the north-eastern extension of the Morwell open-cut area. At Herne's Oak, south of the power-house site, drilling is in progress for brown coal. The brown coal deposits in the vicinity of Corner Inlet are being tested, a drill being worked at present near Gelliondale. Hand-boring is in progress at Wonwron, where a seam 140 ft. in thickness with 8 ft. of overburden was proved. Near Winchelsea, a deposit of brown coal was brought under notice, and further testing of this deposit is now in hand. At Yaloak Vale, south-east of Ballan, a bed of brown coal averaging 4 ft. in thickness was opened, and tests of this deposit are in progress. On the eastern side of the Koo-wee-rup Swamp boring has been commenced, with a view to finding brown coal in this vicinity. In the South Gippsland fields an area of 600 miles was surveyed. This now completes the topography and geology of the country from a line south of Warragul eastwards to Rosedale, and from the Melbourne-Sale railway line to the Melbourne-Port Albert line. Boring has been continued in the vicinity of Korumburra for black coal, and while the results have so far proved only small seams the increasing demand for black coal for locomotive use and gas purposes warrants still further search in this area, where a drill is now at work. Subsidized boring for the Jumbunna Co. has led to the extension of the known area of coal within their lease. A detail survey of the parish of Tanjil East has just been completed, and the result was availed of by the electricity commissioners in connection with their work.

In the Narracan district further outcrops of bauxite have been discovered, and with the advent of cheap power from the Morwell scheme the production of aluminium may be possible in the near future. At Nowa Nowa an examination of the iron deposits was made and data collected, which led to new interest being

directed to the locality. Sands for the manufacture of superior qualities of glass were examined in the Otway Ranges, and their suitability demonstrated by laboratory tests. In the north-east of the State surveys are being continued. Plans of the parishes of Walwa, Thologolong, Burrowye, and Koetong were issued recently. The geology of this area is of interest, as forming a correlation of the Victorian and New South Wales mineral belts. On the plans the outcrop of lodes containing molybdenite, wolfram, scheelite, tin, and fluor-spar are shown. The fluor-spar lodes are now attracting attention, as are also the scheelite and wolfram veins.

VANCOUVER, B.C.

FIRE AT BRITANNIA MILL.—On the night of March 19 the Britannia Mining & Smelting Company's 2,500-ton concentrating plant was completely destroyed by fire. The loss is estimated at one and a half million dollars, only part of which is covered by insurance. The mill, which was the largest and most complete in the Province, consisting of jigs, tables, and flotation cells, took more than a year to build, and was finished only in 1916. The Britannia is a subsidiary of the Howe Sound Mining & Smelting Company, and is the most financially solid copper concern in the Province. The mill was closed on November 30, on account of the low price of copper, but between two and three hundred men have been steadily employed throughout the winter on development work. The fire is supposed to have been due to a short-circuit, as the electric lamps gave a flicker before the fire broke out. The fact of the mill being closed at the time and the fire-fighting appliances being inside, delayed access to this apparatus, and undoubtedly was the cause of the total destruction of the mill. The fire is supposed to have been accelerated, too, by the fact that it broke out near to where the flotation-oil was stored, and it is thought that this oil added considerably to the speed with which the fire spread, as the whole building seemed to be in flames within a few minutes after the outbreak. Fortunately, the men were able to confine the fire to the mill, so no men will be thrown out of work by the conflagration. It had been the intention of the company to re-start the mill this spring. The president of the company, E. B. Schley, is in Europe, and until he has been consulted plans for rebuilding cannot be made. There is no doubt, however, but that the mill will be rebuilt. The Britannia has an actual ore-reserve of more than nine million tons that will average 2% copper and a small gold and silver content. Last year the company turned out 18 million pounds of copper. The concentrate made at Britannia Beach, in Howe Sound, is smelted in Tacoma, in the State of Washington.

PREMIER.—After a short spell of mild weather, which caused a temporary cessation in the transport of ore from the Premier mine to Stewart, cold weather has set in again, and shipping has been resumed. The Prince Albert, which sailed from Stewart on March 20, brought 700 tons of ore, valued at about $300,000, from the Premier to the Tacoma smelter. The contract for the aerial tramway has been let to the Riblet Tramway Company, of Spokane, Washington. The tramway will be between 11 and 12 miles long, and there is a fall of 1,400 ft. between the mine and tide-water. Ore-bunkers, with an automatic unloading device, are to be erected near the wharf at Stewart. The tramway will cost in the neighbourhood of a quarter of a million dollars. It is hoped that the heavy machinery may be hauled to the mine before the present hard crust of ice breaks, as this would considerably hasten the speed of construction.

YUKON LEAD.—The Dominion Government has granted incorporation to the Mayo Valley Railway, Ltd., for the purpose of building a line 50 miles in length along the Mayo and Stewart rivers to open up the new silver-lead mining district in the Yukon Territory. Considerable work has been done during the winter at this camp, and the Yukon Gold Mining Co., the biggest operator, already has more than 2,000 tons of ore at Mayo Landing. This ore is said to average 200 oz. silver per ton and 65% lead. It is expected that another 1,000 tons will be delivered at the Mayo Landing before navigation opens.

OIL INVESTIGATIONS.—There has just been published from the Provincial Department of Lands a pamphlet, entitled "Report of the Oil Surveys of the Peace River District," by John A. Dresser and Edmund M. Spieker. Professors Dresser and Spieker were employed by the Department of Lands to complete the work started by the late J. C. Gwillim in the summer of 1919, and they spent July, August, and part of September in the district last year. Professor Dresser and his assistants made a survey of the ground immediately west of the Peace River Block, which is a Dominion Government forest-reserve, while Professor Spieker surveyed a strip of land some 10 miles wide and 40 miles long trending in a south-east direction immediately south of the Peace River Block. Neither geologist found indications of

oil, but both found geological formations suitable for its retention and similar to that in which oil occurs in other parts of western Canada. Professor Dresser sums up as follows: "The character of the St. John shales strongly suggests that they are oil-bearing, but accumulations of commercial value can only be expected in the porous sandstone beds within the shales or in the upper part of the Bullhead sandstones immediately beneath them. Such accumulations are most likely to occur in the folds of the rocks, principally in anticlinal or upward folds. Along the Peace River one such fold appears near Hudson Hope and another at the "Gates" of the Peace, 7 miles lower down the river. Other folds, probably related to these, were also found on the Red River, near the trail of the South-west Halfway; on Lynx Creek, near to the trail leading to the forks of the Halfway; and on the South-west Halfway, near the trail leading to Hudson Hope. These are the most promising localities for the discovery of oil yet found in the area. In view of the unlikelihood of finding better structures and of the limited amount of other information likely to be obtained in the area by further field examination alone, it seems advisable that the next step in search of oil should be made by exploratory drilling."

Professor Spieker, with regard to the land he surveyed, sums up: "A conclusion regarding the advisability of exploration with the drill must naturally be based on the balancing against one another of the favourable and unfavourable facts (not opinions) which have been gathered. Without attempting at the differentiation of geologic and economic data, these facts may be summed up as follows: Unfavourable factors: (1) Absence of evidence through seepage or other appearance of petroleum in the rocks; (2) the great cost of transporting drilling equipment to any of the advisable locations; (3) in corollary of the preceding, the expense attached to the disposal of such petroleum as might be found. Favourable factors: (1) The presence of a number of locations in which oil could occur; (2) the presence of anticlines which dispose the possibility of oil-bearing strata favourably to the retention of petroleum; (3) the comparatively reasonable depth within which the beds to be tested may be reached. As a whole the region may be classed on the basis of geologic evidence as a fair prospect."

Some two years ago, the D'Arcy Development Company, a subsidiary of the Anglo-Persian Oil Company, sought from the Provincial Government the sole right to explore over an area 70 miles square in this district, agreeing within 5 years to select an area 10 miles square, and surrendering the balance to the Province. The company further agreed that, in the event of the discovery of petroleum in commercial quantities, it would construct pipe-lines or provide other means to make it available and would pay a royalty of 12 cents per barrel at the casing head. The majority of the mining engineers in the Province are agreed that the Government made a mistake in not accepting this offer. The Government, however, claims that it is preserving the oil lands of the Province for the benefit of the Empire. Exactly what value to the Empire the oil areas of the Peace River district could ever be in their present undeveloped state none but the Government can fathom.

TORONTO.

April 12.

PORCUPINE.—The power situation, which has latterly been improving, is now completely satisfactory, and the mining companies are receiving their full requirements. Production at the Hollinger Consolidated, Dome Mines, and McIntyre is now being speeded up, with the output closely approaching the normal volume. Labour is plentiful and efficient. Many miners, released from the silver and nickel camps, are flocking into Porcupine. The Hollinger and the McIntyre are making every effort to find accommodation for the new-comers, and are erecting a number of additional houses for their employees. The drawbacks of power shortage and labour scarcity having ceased to hamper production, a period of great activity is anticipated. The Hollinger has ordered 30 additional machines for underground work so as to take on additional forces. At the Dome Mines two large ore-bodies have been encountered at the 1,050 ft. level, the ore showing considerably higher gold content than the average. The ore sent to the mill is now 50% higher in gold content than the pre-war grade. The North Crown has struck rich ore in a drift at the 500 ft. level, the gold content running as high as $20 per ton across the face of the drift. The Porcupine Keora has arranged to sell two of its claims to a new company to be organized with a capitalization of $3,000,000, two-thirds of the shares to be retained by the Keora. The company will still have three claims with an area of 120 acres. The Allied Porcupine Gold Mines has been organized with $5,000,000 capital to take over the La Palm and Three Nations properties and possibly other holdings. Peter Kirkgaarde, of Toronto, has been placed in charge of opera-

tions. Operations have been resumed at the Premier Paymaster, south-west of the Dome. Diamond-drilling is being undertaken to determine the extension eastward of a large ore-body opened up on the 200 ft. level. The Porcupine Miracle, which is preparing for active development, has increased its capitalization from $1,000,000 to $2,000,000.

KIRKLAND LAKE.—The season has opened actively in this camp with quite a number of new enterprises entering the field, especially in Lebel Township. The Lake Shore during February produced $24,068 from the treatment of 1,458 tons of ore, being an average extraction of $16·44 per ton, the mill running 83% of possible time. The Kirkland Lake has encountered a new ore-shoot on the 700 ft. level, which has been opened up for 100 ft. The drift on the 600 ft. level has entered the same body. Development work is being carried on at five levels. At the King Kirkland the shaft is down 100 ft. on a vein the full width of the shaft with highly satisfactory results. Assays of channel-samples taken at intervals down give varying results, with an average of $11·60 per ton. A new company, the Queen Lebel, has been formed to take over three mining claims lying south of the east end of Gull Lake, on which a number of promising veins have been found. The shaft of the Lebel-Oro has reached a depth of 50 ft. on a vein carrying commercial gold content. The Kirk Gold Mines is making arrangements to operate three claims adjoining the King Kirkland on the west in the line of the strike of the ore-bodies found in the producing area. The Teck Hughes mill is working to capacity, treating about 125 tons of ore per day. The company is planning to increase its milling equipment. The Bidgood will undertake a large amount of underground work, including the deepening of the main shaft from 300 to 500 ft. D. H. Angus, of Cobalt, has been placed in charge.

COBALT.—The silver-mining industry continues much depressed. It is hoped, however, that the new wage schedule, under which wages are cut 75c. per day, which went into effect on April 1, may result in some revival of activity. It is estimated that the lower wage means a reduction of from 3 to 5c. per oz. in mining costs, which may give some mines now idle an opportunity for profitable operation. The Nipissing during February produced silver to the value of $111,931 and cobalt valued at $12,460, and shipped bullion from Nipissing and custom ores of an estimated net value of $235,374. The annual report of the La Rose for 1920 showed that production amounted to 410,445 oz., valued at $313,995, compared with 289,317 oz. of the value of $356,124 in 1919. The profit on production was $13,279. While there are several sections of the parent property which will warrant further investigation, G. C. Bateman, the general manager, does not consider that the work would be justified at present owing to the low price of silver. A quantity of exceptionally rich ore is being taken from the University property of the La Rose. The Mining Corporation of Canada is making extensive alterations in its mill, designed to increase the capacity from 200 to 300 tons daily. It will require at least a month longer to complete this work, and in the meantime productive activity will remain suspended. The Kerr Lake has exercised its option on the Hargraves property adjoining, which it is operating from its own underground workings. The Northern Customs Concentrators, Ltd., has gone into liquidation.

SUDBURY.—The first mortgage bond-holders and debenture stock-holders of the British American Nickel Corporation have approved a scheme for the financial reorganization of the company by the issue of $24,500,000 in income bonds of three classes, a portion of which will be hypothecated for debts, $2,000,000 retained in the treasury, and the remainder exchanged for first mortgage bonds and debenture stock. Minority interests are taking legal proceedings to prevent the arrangement being carried out.

FLIN-FLON.—The New York syndicate, headed by Col. W. B. Thompson, which held an option on the Flin-Flon copper deposit in Northern Manitoba which expired March 31, allowed it to lapse after having expended over $200,000 in development work. The low price of copper and the tightness of the money market are the reasons assigned for failing to take over the property. The ore-body is estimated at about 24,000,000 tons, but its operation, including the construction of a railway, the establishment of a new mining town, and the development of power, might involve a total expenditure of $20,000,000. Negotiations are now under way for the purchase of the mine by a new syndicate, headed by the Mining Corporation of Canada, which held a fourth interest in the New York syndicate.

MACKENZIE RIVER OILFIELD.—Interest in the oil discoveries near the Arctic Circle continues active, though prospectors have been somewhat discouraged by the provision in the new regulations under which when a discovery is made three-fourths of the area included in the prospector's licence reverts to the Crown. A number of oil issues, some of them of doubtful character, are being placed on the market.

Representatives of several British companies are in Northern Alberta looking after their interests, and the coming season will witness much activity in exploration. A bill in the interests of the Imperial Oil Co., authorizing the construction of a pipe-line from the Mackenzie River oilfield, is before the Alberta Legislature. It is meeting with strong opposition from other interests, who contend that any pipe-line authorized to be built should be constituted a common carrier, available for the product of all operators, and not a monopoly.

PERSONAL.

CLYDE ALLEN is expected from Nigeria.

DR. CHARLES ANDERSON has been appointed Director of the Australian Museum, Sydney.

PROFESSOR C. O. BANNISTER, of Liverpool University, is the recipient of an Andrew Carnegie Research Award of £100.

F. O'D. BOURKE is here from Nigeria.

W. E. CAMERON has been appointed Mining Geologist to the Federated Malay States Government.

A. D. COMBE has been appointed Assistant Government Geologist in Uganda.

W. H. CORBOULD is expected from Mount Elliott, Queensland.

PAUL S. COULDREY has left British Columbia to take an appointment in Spain.

CLEMENT DIXON is visiting Central Europe.

W. R. FELDTMANN is back from West Africa.

B. L. GARD'NER has left for Selangor to take up an appointment as Inspector of Mines.

PHILIP GRIMLEY is home from Nigeria.

DR. J. A. L. HENDERSON is back from Canada.

HARLEY E. HOOPER has returned to Adelaide from Burma, where he was for some years on the staff of the Kanbauk Burma Wolfram Mines company.

J. M. ILES is here from Nigeria.

A. F. KEENE is here from New York.

ELDRED A. KNAPP has gone to Venezuela.

H. W. LAWS has returned from Nigeria.

ARTHUR E. LEWIS has gone to Ipoh, Perak.

EDWARD P. MATHERS has gone to South Africa.

E. P. MATHEWSON will be leaving shortly on his return to New York.

L. H. McLAGGAN has returned from West Africa.

A. H. P. MOLINE has been here from Australia, and is returning by way of South Africa.

C. ALGERNON MOREING has had conferred on him by the President of the French Republic the Order of the Legion of Honour.

R. J. MORGAN has returned to Sydney from Siberia.

CLIFFORD W. NASH has opened an office in Melbourne, where he will practice as a consulting metallurgist.

J. A. T. ROBERTSON has left Missouri for Yunnan.

W. R. RUMBOLD is back from Portugal.

WILLIAM SELKIRK has returned from India.

R. C. SHARP has returned from South America.

RALPH S. G. STOKES, assistant general manager in the mining department of the De Beers Consolidated Mines, is visiting England on long leave.

DR. O. J. STANNARD is back from the United States.

H. PLAYFORD TUCK has joined the staff of the Electrolytic Zinc Co. of Australasia in Tasmania.

PAUL M. TYLER is here from the United States.

F. G. WILSON has been appointed manager for the Austral Siamese Tin Company.

YEATMAN & BERRY have moved their office from 111, Broadway, to Room 1,604, 165, Broadway, New York.

T. E. GATEHOUSE, for forty years editor of the *Electrical Review*, died on March 31. He was an editor of discrimination and high honour, and he was also endeared among the electrical profession by being a musician and violinist of no mean order.

BERTRAM BLOUNT died last month in his 54th year, after a long illness which supervened on strenuous war work. He was known in many departments of chemical engineering, and wrote books on cement, electrochemistry, and chemistry for engineers. His paper and investigations on the accuracy of chemical balances aroused much attention among metallurgists; this matter was referred to in our pages early in 1918.

A. J. C. MOLYNEUX, a member of the Rhodesian Geological Survey, died last December. He originally went to Rhodesia in 1893 with Major Alan Wilson's force which occupied Matabeleland. After the country was settled, he made many geological expeditions. His most important work was the discovery of several of the coalfields in Rhodesia, and his correlation of these deposits with the Karroo Coal Measures. He was the founder and first secretary of the Rhodesia Scientific Association, and one of the first trustees of the Rhodesia Museum. He joined the Geological Survey in 1917.

RICHARD A. VARDEN died last month. He was a graduate of Clausthal, and his first appointment was at the Wohlfart mines in Germany. Subsequently he went to the United States and Mexico. In 1895 he went to West Australia as manager of Hannan's Brownhill mine. In 1897 he joined Bainbridge, Seymour & Co. as Australian partner, and later became a London partner of the firm. In 1910 he became Australian partner of Hooper, Speak & Co., and continued in that capacity until 1918, when he retired from active practice. While in Australia for Hooper, Speak & Co., he was chiefly concerned in the management of Great Boulder Perseverance and Ida H. He was a man of singular charm and high character. That he lived so much abroad was always regretted by his confreres in England.

TRADE PARAGRAPHS

THE HENRY WELLS OIL CO., of 11, Haymarket, London, S.W.1, send us a pamphlet describing the "Germ Process" lubricating oils.

THE SWAINSON PUMP CO., LTD., of Newcastle-on-Tyne, have put on the market a new hand-pump suitable for use in mines.

BULLIVANT & CO., LTD., of 72, Mark Lane, London, E.C.3, and Millwall, send us a copy of their revised catalogue of steel wire ropes and accessories. The catalogue contains illustrated descriptions of a great variety of applications of the firm's ropes.

THE EDGAR ALLEN NEWS for May, published by EDGAR ALLEN & CO., LTD., Imperial Steel Works, Sheffield, contains articles on the design of furnaces for heat treatment by S. N. Brayshaw, and on the importance of shape in rock-drill bits.

THE WESTINGHOUSE ELECTRIC INTERNATIONAL CO., of 165, Broadway, New York, publish a monthly magazine called the "Westinghouse International." The April issue deals with several of the firm's specialties and also with the outlook throughout the world for electrical business.

METROPOLITAN-VICKERS ELECTRICAL CO., LTD.,

of Manchester, and 4, Central Buildings, Westminster, send us leaflets describing high-tension contactor panels and Star-Delta contactor starters; also a pamphlet relating to the installation and operation of the firm's power transformers. They also send us their pamphlets relating to their turbo-alternators and electric arc welding.

THE ENGLISH ELECTRIC CO., LTD., of Queen's House, Kingsway, London, W.C.2, send us a new publication relating to steam turbines. This firm is a recent consolidation of Dick, Kerr & Co., of Preston, the Siemens Dynamo, of Stafford, Willans & Robinson, of Rugby, the Phœnix works, Bradford, and the Ordnance works, Coventry. The steam turbines of this firm are specially adapted to the driving of great alternating-current dynamos.

SIR W. G. ARMSTRONG, WHITWORTH & CO., LTD. (civil engineering and contracting department, 8 & 10, Great George Street, Westminster), have obtained the contract from the Crown Agents for the Colonies for the Ebute Metta workshops, which are to be erected near Lagos for the Nigerian Government Railways. The contract calls for the supply, erection, and equipment of new locomotive shops, carriage and wagon shops, an electric power station, saw-mills, etc.

SUBMERSIBLE MOTORS, LTD., of Southall, near London, have issued particulars of their electrically-driven pumps for mines. The vertical type of submersible motor-pump is adapted for use in sinking operations. The construction is such that the apparatus takes up very little room in the shaft; there are no awkward or projecting corners and angles; the pump can be very quickly slung in chains or on ropes; and it is immaterial as to what angle the pump is suspended. The advantage of being able to lower the pump and motor into water until the apparatus is either wholly or partly submerged without it losing in reliability or efficiency is incalculable. Sinkers frequently use these pumps as a standing, when drilling their sumping and side holes. The horizontal type is adaptable for practically any emergency in mines, and can be installed at a shaft bottom or any part of mine workings with complete confidence and safety. In cases of accumulations of water, in dip or deep workings, a submersible motor pump is of peculiar advantage. In these cases the apparatus can be securely fastened to a skid or low trolley and lowered completely into the water. No undulations of the floor, in whatever direction, have any adverse effect on the pumps. The reliability of these pumps can be exemplified by the installation at Pengam Colliery in Monmouthshire. Here a 6 in. single-stage pump was started on May 6, 1920, and has been continuously at work for over nine months, for the greater part of the time running 24 hours per day for weeks together. During the whole period the motor-pump was working entirely submerged, and has only been raised twice for examination, when everything was found to be in excellent condition.

THE BUILDING TRADES EXHIBITION, OLYMPIA.

The Building Trades Exhibition at Olympia was open for two weeks, from April 12 to 26, and attracted a large number of visitors. To mining engineers concerned in the housing of their employees it offered many points of interest, particularly in regard to the materials of which houses may be built nowadays. There were many exhibits by firms known among mining men, of which brief notes are given in the following paragraphs.

G. A. HARVEY & CO. (LONDON), LTD., of 5, Laurence Pountney Hill, London, E.C.4, and Woolwich Road, E.14, showed galvanized iron tanks and also screens of perforated metal and woven wire.

THE MOLER FIRE-PROOF BRICK & PARTITION CO., LTD., one of the Vickers group of companies housed at Vickers House, Broadway, Westminster, with works at Colchester, had an exhibit of fire-proof and sound-proof bricks, and bricks suitable as insulating boiler coverings. The material used is diatomaceous earth obtained from Denmark. The deposit was described by E. A. Manners in the MAGAZINE for March, 1916.

FERODO, LTD., of Chapel-en-le-Frith, showed their fibre stair treads. Ferodo is known among engineers as a surface material for brakes and clutches.

THE STURTEVANT ENGINEERING CO., LTD., of 147, Queen Victoria Street, London, E.C.4, confined their exhibit to ventilating fans and vacuum cleaners.

THE WILFLEY COMPANY, LTD., of Salisbury House, London, E.C.2, showed their Marbolith jointless flooring.

JOHN & EDWIN WRIGHT, LTD., of the Universe Rope Works, Birmingham, and Salisbury House, London, E.C.2, had an excellent display of their hemp and steel wire ropes.

MILLARS TIMBER & TRADING CO., LTD., of Pinners Hall, London, E.C.2, had an exhibit of rock crushers and air-compressors, and illustrations and models of steam-shovels, cranes, and other machinery.

S. THORNLEY MOTT & VINES, LTD., of 11, Old Queen Street, Westminster, showed "ironite" cement and flooring, hollow concrete blocks for building purposes, Watson bottom-dumping wagons, and concrete mixers. They also showed photographs of the Marion steam-shovel, for which they are agents in this country.

We also observed applications of the DORR plant to sewage treatment and NISSEN huts; these were shown by users and not by the manufacturing firms.

Ready access to the galleries was provided by a special exhibit of lifts made by WAYGOOD-OTIS, LTD., of 54 and 55, Fetter Lane, London, E.C.4.

METAL MARKETS

COPPER.—Remarkable steadiness characterized the London standard copper market during April, and price fluctuations have been very small, despite the coal stoppage and the threat, happily unfulfilled, of a general strike. The fact that demand from consumers is still poor and likely to diminish further under present industrial conditions seems to have had little influence on values, and there is quite an optimistic undertone in the market. In the United States, the price has kept steady around 12¾ cents per lb., and business there is also quiet. During the first quarter of the year, stocks in that country increased, but in view of the recent closing of a dozen or so important mines, production will show a falling off in the near future, and a decrease in the huge American stocks is to be expected. It is understood, by the way, that it will be possible to restart the mines there at very short notice when conditions are favourable to such a policy. The Kennecott Copper Corporation has cut down production, and may later close down completely. The Braden concern has reduced output to some 1,000 tons. Neither the Chile nor Braden companies is expected to shut down, however. The Quincy Mining Co. at Calumet has reduced wages by 10%. Chilean mines, it is understood, are to restrict production, but the Union Minière du Haut Katanga is undertaking fresh development schemes and has no apparent intention of adopting a similar policy.

Average price of cash standard copper: April 1921, £69. 8s. 11d.; March 1921, £67. 13s. 3d.; April 1920, £103. 2s. 11d.; March 1920, £109. 11s. 10d.

TIN.—The standard tin market in London was domi-

Daily London Metal Prices: Official Closing
Copper, Lead, Zinc, and Tin per Long

	Copper				
	Standard Cash	Standard (3 mos.)	Electrolytic	Wire Bars	Best Selected
April	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.
11	69 5 0 to 69 7 6	69 5 0 to 60 7 6	72 10 0 to 74 0 0	73 10 0 to 74 0 0	70 0 0 to 72 0 0
12	69 0 0 to 69 2 6	69 2 6 to 69 5 0	72 10 0 to 74 0 0	73 10 0 to 74 0 0	70 0 0 to 72 0 0
13	69 0 0 to 69 2 6	69 2 6 to 69 5 0	72 10 0 to 74 0 0	73 10 0 to 74 0 0	70 0 0 to 72 0 0
14	68 12 6 to 68 15 0	68 15 0 to 69 0 0	72 0 0 to 74 0 0	73 0 0 to 74 0 0	70 0 0 to 72 0 0
15	69 0 0 to 69 2 6	69 5 0 to 69 7 6	71 0 0 to 74 0 0	73 0 0 to 74 0 0	69 0 0 to 71 0 0
18	69 15 0 to 69 17 6	70 0 0 to 70 2 6	71 0 0 to 74 0 0	73 0 0 to 74 0 0	69 0 0 to 71 0 0
19	69 15 0 to 69 17 6	70 0 0 to 70 2 6	71 0 0 to 74 0 0	73 0 0 to 74 0 0	71 0 0 to 73 0 0
20	70 2 6 to 70 5 0	70 10 0 to 70 12 6	71 0 0 to 74 0 0	73 0 0 to 74 0 0	71 0 0 to 73 0 0
21	69 7 6 to 69 12 6	69 15 0 to 70 0 0	71 0 0 to 74 0 0	73 0 0 to 74 0 0	71 0 0 to 73 0 0
22	69 17 6 to 70 0 0	70 2 6 to 70 5 0	71 0 0 to 74 0 0	73 0 0 to 74 0 0	71 0 0 to 73 0 0
25	70 0 0 to 70 2 6	70 7 6 to 70 10 0	71 0 0 to 74 0 0	73 0 0 to 74 0 0	71 0 0 to 73 0 0
26	70 5 0 to 70 7 6	70 10 0 to 70 15 0	72 0 0 to 74 0 0	73 0 0 to 74 0 0	71 0 0 to 73 0 0
27	70 0 0 to 70 2 6	70 2 6 to 70 5 0	72 0 0 to 74 0 0	73 0 0 to 74 0 0	71 0 0 to 73 0 0
28	70 10 0 to 70 12 6	70 5 0 to 70 7 6	72 0 0 to 74 0 0	73 0 0 to 74 0 0	71 0 0 to 73 0 0
29	70 7 6 to 70 10 0	69 17 6 to 70 0 0	72 0 0 to 73 10 0	72 10 0 to 73 10 0	71 0 0 to 73 0 0
May					
2	70 10 0 to 70 15 0	69 15 0 to 70 0 0	71 0 0 to 73 0 0	71 0 0 to 73 0 0	71 0 0 to 73 0 0
3	71 5 0 to 70 10 0	69 15 0 to 70 0 0	72 0 0 to 73 0 0	72 0 0 to 73 0 0	72 0 0 to 74 0 0
4	71 10 0 to 72 0 0	70 2 6 to 70 5 0	72 0 0 to 73 0 0	72 0 0 to 73 0 0	72 0 0 to 74 0 0
5	72 10 0 to 72 15 0	70 10 0 to 70 15 0	72 10 0 to 73 10 0	72 10 0 to 73 10 0	72 0 0 to 74 0 0
6	72 10 0 to 72 15 0	71 0 0 to 71 5 0	72 10 0 to 73 10 0	72 10 0 to 73 10 0	72 10 0 to 74 10 0

nated at the beginning of the month by the coal crisis, and quotations were accordingly depressed. Later, values fluctuated upon every fresh development in the industrial situation, optimism finally gaining the upper hand, with the consequence that prices at the end of the month showed a moderate rise. There had been a general feeling that the bottom had been reached, and the upward reaction was therefore not altogether unexpected. Consuming demand, however, still continues unsatisfactory, and purchases by the Continent have rather tended to fall off of late. Stocks, on the other hand, are well held both here and in the East. Of course, the Federated Malay States Government holds a considerable quantity of metal, acquired at comparatively high prices, but the intention is to wait for a more remunerative level of quotations before liquidating. It had been expected that the Straits mines and smelters would commence curtailing output, but up to the present no definite news is to hand as to what has been done in this direction, although the Nigerian and Bolivian mines have found themselves forced to adopt such a policy. Apropos the general impression that profitable tin production in the Straits is difficult at current market values, it is interesting to observe that the Gopeng company's cost of producing black tin last year was £59. 2s. 3d. (average profit £122. 14s. 4d.), the Rambutan's cost £73. 7s. 3d. (average profit £116. 17s. 6d.), and Tekka-Taiping's cost £69. 3s. 4d. (average profit £108. 2s. 8d.). The Nigerian companies appear to have been harder hit by the fall in tin, and have successfully applied for concessions from the Government in regard to rents and royalties in order to give them some relief. The Straits have been shipping only moderately of late, the figure for April being 1,800 tons, of which 715 tons came to the United Kingdom, 925 tons were taken by the United States, and 100 were despatched to the Continent.

Average price of cash standard tin: April 1921, £164 0s. 11d.; March 1921, £156. 4s. 7d.; April 1920, £345. 13s. 1d.; March 1920, £369. 14s. 5d.

Lead.—The London lead market has kept fairly steady during the past month, the tendency being slightly upwards. Undoubtedly, the feature has been the purchases of Spanish lead direct by America, which has had the effect of somewhat reducing the arrivals in this country. The American buying has been influenced by the apprehension of increased import tariffs in the near future. Practically the only supplier of lead to the London market has been Spain. America is above our parity, Burma sells to the East, the situation in Australia does not permit of supplies from there, while Belgium and Germany send nothing. It was believed that the stocks in Spain were considerable, but owing to the lack of information on the position there it is not known whether further heavy shipments are likely. It is possible, of course, that the United States may later re-export some of the metal recently purchased. News from the producing countries tells invariably of curtailed output. At Fremantle, the smelter of the Fremantle Trading Co. has been shut down owing to the ceasing of supplies from the neighbouring mines. The Chihuahua and Monterey smelters in Mexico have closed indefinitely, while Spanish advices state that the Penarroya Co. has stopped work at the Santa Isabella mines. As regards the United States production, this appears to be generally curtailed except in some cases where the ore is mined for its silver. Stocks in the United States are reported to be large. The March production of lead of the Rhodesia Broken Hill was 1,630 tons.

Average price of soft pig lead: April 1921, £20. 16s. 10d.; March 1921, £19. 2s. 9d.; April 1920, £40. 4s.; March 1920, £47. 1s. 9d.

Spelter.—The London spelter market during April had a firm tendency, prices rising very gradually but steadily. The chief reason for this was no doubt the absence of offers of German metal, owing to the deadening influence of the Reparations Act, and the better sentiment thereby engendered. As long as the Act remains in force, it is difficult to see how Germany, which is believed to be the only producer to whom the present London price is profitable, can continue to export; while the other producers are naturally averse from doing so because prices are too low. Both Belgium and Norway appear to be looking for higher levels before entering the market on a large scale, and America also is not likely to ship anything to this side. Under these circumstances, despite the fact that consuming demand is generally poor owing to the unsatisfactory condition of the galvanizing industry, the tendency certainly appears to be toward higher prices. The Belgian produc-

PRICES ON THE LONDON METAL EXCHANGE.
Tons; Silver per Standard Ounce; Gold per Fine Ounce.

Lead		Zinc (Spelter)	Standard Tin		Silver		Gold	
Soft Foreign	English		Cash	3 mos.	Cash	Forward		
£ s. d. £ s. d.	£ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.			s. d	April
20 15 0 to 21 5 0	22 5 0	25 15 0 to 27 0 0	163 0 0 to 163 5 0	165 15 0 to 166 0 0	$34\frac{1}{2}$	$34\frac{1}{8}$	104 10	11
20 17 6 to 21 10 0	22 5 0	25 12 6 to 26 17 6	161 10 0 to 162 0 0	165 [illegible] 0 to 165 5 0	$36\frac{1}{2}$	36	104 10	12
20 15 0 to 21 7 6	22 5 0	25 10 0 to 26 10 0	157 0 0 to 157 10 0	161 0 0 to 161 5 0	$34\frac{7}{8}$	$34\frac{1}{2}$	105 1	13
20 10 0 to 21 2 6	22 0 0	25 5 0 to 26 5 0	159 0 0 to 159 5 0	162 5 0 to 162 10 0	$34\frac{1}{8}$	$33\frac{7}{8}$	105 4	14
20 10 0 to 21 2 6	22 0 0	25 10 0 to 26 10 0	160 15 0 to 161 0 0	164 5 0 to 164 10 0	$33\frac{3}{4}$	$33\frac{3}{8}$	104 11	15
20 12 6 to 21 5 0	22 5 0	25 17 6 to 27 0 0	169 0 0 to 169 5 0	171 5 0 to 171 10 0	$35\frac{5}{8}$	$34\frac{7}{8}$	104 8	18
20 12 6 to 21 7 6	22 5 0	26 0 0 to 27 0 0	168 0 0 to 168 5 0	169 15 0 to 170 0 0	$34\frac{1}{2}$	$34\frac{3}{8}$	104 8	19
21 0 0 to 21 12 6	22 10 0	26 0 0 to 26 17 6	166 15 0 to 167 0 0	169 0 0 to 169 5 0	35	$34\frac{1}{8}$	104 8	20
21 5 0 to 21 15 0	22 15 0	26 10 0 to 27 5 0	168 15 0 to 169 0 0	171 5 0 to 171 10 0	$34\frac{1}{8}$	$34\frac{1}{8}$	104 8	21
21 2 6 to 21 12 6	22 15 0	26 5 0 to 27 0 0	168 15 0 to 169 0 0	171 10 0 to 171 15 0	$34\frac{5}{8}$	$34\frac{1}{4}$	104 10	22
20 15 0 to 21 5 0	22 5 0	26 0 0 to 27 0 0	174 0 0 to 174 5 0	176 15 0 to 177 0 0	$34\frac{5}{8}$	$34\frac{1}{4}$	104 3	25
20 17 6 to 21 7 6	22 5 0	26 5 0 to 26 17 6	173 15 0 to 174 0 0	176 5 0 to 176 10 0	$34\frac{5}{8}$	$34\frac{1}{4}$	104 2	26
20 17 6 to 21 7 6	22 5 0	25 15 0 to 27 0 0	172 0 0 to 172 5 0	174 10 0 to 174 15 0	$34\frac{5}{8}$	$34\frac{1}{4}$	104 2	27
21 2 6 to 21 12 6	22 10 0	26 5 0 to 27 0 0	172 0 0 to 172 5 0	174 15 0 to 175 0 0	$34\frac{3}{4}$	$34\frac{3}{8}$	104 3	28
21 7 6 to 21 15 0	22 15 0	26 0 0 to 27 0 0	171 10 0 to 171 15 0	174 0 0 to 174 5 0	$34\frac{5}{8}$	$34\frac{1}{4}$	104 1	29
								May
21 10 0 to 21 15 0	22 15 0	25 15 0 to 27 0 0	169 10 0 to 170 0 0	171 10 0 to 172 0 0	$34\frac{7}{8}$	$34\frac{1}{2}$	103 8	2
21 17 6 to 21 17 6	23 0 0	25 7 6 to 26 12 6	168 0 0 to 168 5 0	170 10 0 to 170 15 0	$34\frac{7}{8}$	$34\frac{1}{2}$	103 8	3
22 5 0 to 22 5 0	23 10 0	25 10 0 to 26 15 0	169 10 0 to 169 15 0	172 0 0 to 172 5 0	35	$34\frac{3}{8}$	103 3	4
22 10 0 to 22 10 0	23 10 0	26 0 0 to 27 5 0	176 0 0 to 176 10 0	178 10 0 to 178 15 0	$35\frac{1}{4}$	$34\frac{7}{8}$	103 4	5
22 15 0 to 22 12 6	23 15 0	26 0 0 to 27 5 0	177 10 0 to 177 15 0	179 15 0 to 180 0 0	$34\frac{3}{4}$	$34\frac{1}{8}$	103 4	6

tion during March showed a reduction on the month of 1,890 tons, being only 4,640 tons. The German output is estimated at around 4,000 tons monthly, but present conditions may force curtailment there also. Belgium is apparently finding a ready market in France and elsewhere for her zinc sheets, so it is more than probable that her stocks will find an outlet in that direction rather than be unloaded on the London market. As regards the American position, the present output there has been estimated at about one-third of what it was a year ago, while stocks are believed to be double. The American quotation has been firmer during the month.

Average price of spelter: April 1921, £26. 1s. 5d.; March 1921, £25. 10s. 5d.; April 1920, £48. 9s. 4d.; March 1920, £54. 16s. 7d.

ZINC DUST.—Business has been quiet, and prices are practically unaltered on the month, as follow: High-grade Australian about £55, high-grade American £55 to £62. 10s., and best English about £60 per ton. Continental material appears to be offering at lower figures.

ANTIMONY.—English regulus has kept steady at £37 to £40 for ordinary brands and at £38. 5s. to £42 for special brands. Foreign regulus on spot is quoted around £25 to £28 per ton in warehouse.

ARSENIC.—The market is stagnant, and Cornish white is nominally quoted at £46 to £48 per ton delivered.

BISMUTH.—The leading interests quote 7s. 6d. per lb.

CADMIUM.—There is only a small demand, but the price is steady at 6s. to 6s. 3d. per lb.

ALUMINIUM.—Producers are nominally quoting £150 per ton for both home and export, but this price would possibly be shaded, especially as there have recently been offers of cheap Continental metal.

NICKEL.—The chief interests made two reductions of £5 in the price during April, and the present quotation is £190 per ton for both home and export.

COBALT METAL.—Demand is quiet, the price being 18s. to 20s. per lb.

COBALT OXIDE.—Black oxide continues at 16s. and grey at 17s. 6d.

PLATINUM AND PALLADIUM.—There is little change to report. The leading sellers of manufactured metal (sheets and wire) have increased their price to £20 per oz. Raw platinum, however, is still reported to be changing hands around £17 per oz. and raw palladium at about £15.

QUICKSILVER. — The market has been easy and quiet. The present quotation is £11. 5s. to £11. 10s. per bottle.

SELENIUM.—The market is quiet, the quotation being 10s. 6d. to 13s. per lb.

TELLURIUM.—Sellers continue to quote 90s. to 95s. per lb.

SULPHATE OF COPPER.—The tendency is still downward, and the present quotation is about £28 to £30.

MANGANESE ORE. — The market is rather quiet, with Indian grades steady at 1s. 4d. to 1s. 5d. per unit c.i.f. U.K.

TUNGSTEN ORES. — This market continues a very difficult one. The current price is about 12s. 6d. per unit, c.i.f., for 65% WO_3, but buyers are waiting for lower figures, while sellers are inclined to hold out for higher prices. Business is consequently restricted.

MOLYBDENITE.—Business is dull, with 85% nominally quoted at 52s. 6d. to 60s. per unit c.i.f. U.K.

CHROME ORES. — The price of Indian and African grades is steady at £5. 10s. to £6 per ton c.i.f. U.K.

SILVER.—The quotation for spot bars at the beginning of April was $32\frac{1}{2}$d., the price rising till $36\frac{1}{2}$d. was attained on the 12th. Subsequently the price fell to $33\frac{3}{4}$d. on the 15th, recovered to $35\frac{5}{8}$d. on the 18th, and later kept fairly steady, closing the month at $34\frac{5}{8}$d.

GRAPHITE.—Madagascar, 80 to 90%, continues to be quoted at £20 to £25 per ton.

IRON AND STEEL.—A further cut in the price of Cleveland pig iron was made at the beginning of April, but any hopes that were anticipated of a revival in trade were dashed to the ground by the coal strike, and the close of the month found production of iron and steel in this country virtually at a standstill. The price of No. 3 Cleveland pig iron is £6 per ton for both home and export, but Belgian foundry iron can be obtained at £5. 5s. c.i.f. It is the same story in the finished iron and steel trades. Most works are closed, and few makers are showing inclination to book for forward delivery, as the whole question depends upon the new basis price of fuel. In the meantime what little business is about is being secured by Continental makers.

STATISTICS.

Production of Gold in the Transvaal

	Rand	Elsewhere	Total	Price of gold per oz.
	Oz.	Oz.	Oz.	
Year 1919	[illegible]	218,820	[illegible]	[illegible]
January 1920	[illegible]	17,208	[illegible]	[illegible]
February	607,918	[illegible]	[illegible]	[illegible]
March	[illegible]	17,391	[illegible]	[illegible]
April	667,926	19,053	[illegible]	102 [illegible]
May	681,551	17,490	[illegible]	105 [illegible]
June	699,199	16,758	[illegible]	102 [illegible]
July	718,521	17,578	[illegible]	105 [illegible]
August	683,604	18,479	[illegible]	112 [illegible]
September	665,486	16,687	[illegible]	115 [illegible]
October	645,819	16,653	[illegible]	117 [illegible]
November	618,525	15,212	[illegible]	[illegible]
December	617,549	[illegible]	[illegible]	115 [illegible]
Total, 1920	7,949,038	204,587	[illegible]	
January, 1921	637,425	14,168	651,593	[illegible]
February	543,767	14,370	[illegible]	[illegible]
March	656,572	14,551	[illegible]	[illegible]

Natives Employed in the Transvaal Mines.

	Gold mines	Coal mines	Diamond mines	Total
January 31, 1920	176,390	12,766	4,796	193,952
February 29	185,185	12,708	5,217	203,110
March 31	188,564	12,788	5,232	206,584
April 30	189,446	12,951	5,057	207,454
May 31	184,722	12,897	4,793	202,412
June 30	179,827	13,036	4,596	197,459
July 31	174,187	13,005	4,521	191,713
August 31	169,263	13,535	4,244	187,042
September 30	163,132	13,716	4,323	181,171
October 31	159,426	13,858	4,214	177,498
November 30	158,773	14,245	[illegible]	176,522
December 31	159,671	14,263	3,340	177,274
January 31, 1921	165,287	14,541	3,319	183,147
February 28	171,518	14,697	1,612	187,827
March 31	174,364	14,906	1,364	190,634

Cost and Profit on the Rand

Compiled from official statistics published by the Transvaal Chamber of Mines. The profit available for dividends is about 65% of the working profit. Figures for yield and profit for 1919 based on par value of gold; subsequently gold premium included.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
Year 1919	24,043,6[illegible]	28 7	22 11	5 6	6,605,509
January, 1920	2,038,092	34 4	24 2	10 2	1,036,859
February	1,869,180	35 1	28 3*	6 10*	644,571*
March	2,188,104	31 8	25 2	6 6	716,610
April	2,065,446	31 5	26 3	5 2	533,940
May	2,117,725	31 9	25 11	5 10	618,147
June	2,146,890	31 10	25 2	6 8	692,510
July	2,194,050	33 6	24 6	9 0	985,058
August	2,057,560	36 11	25 0	11 11	1,226,906
September	1,950,410	[illegible] 11	25 6	13 5	1,276,369
October	1,871,140	39 9	26 1	13 8	1,278,385
November	1,799,710	40 2	26 3	13 1	1,255,749
December	1,797,970	39 11	26 8	13 3	1,193,672
January, 1921	1,895,235	[illegible]	26 3	8 9	829,436
February	1,575,320	35 6	28 6	7 0	550,974

* Results affected by the back-pay disbursed in accordance with new wages agreement.

Production of Gold in Rhodesia.

	1919	1920	1921
	£	oz.	oz.
January	211,917	43,428	46,956
February	220,885	44,237	40,816
March	225,808	45,779	31,995
April	213,160	47,000	
May	218,057	46,266	
June	214,215	45,054	
July	214,919	46,208	—
August	207,339	48,740	
September	223,719	45,471	
October	204,184	47,343	—
November	186,462	46,782	—
December	158,835	46,190	—
Total	2,499,498	552,498	125,767

Transvaal Gold Outputs.

	February Treated	February Yield	March Treated	March Yield
	Tons	Oz.	Tons	Oz.
Aurora West	[illegible]	£10,030†	10,000	£14,595†
Brakpan	[illegible]	[illegible]	[illegible]	22,339
City Deep	52,500	[illegible]	85,000	36,584
Cons. Langlaagte	[illegible]	[illegible]	42,000	£62,419†*
Cons. Main Reef	33,000	11,515	47,800	16,759
Crown Mines	124,000	42,328	187,000	51,218
Durban Roodepoort Deep	24,550	7,719	26,500	8,778
East Rand P.M.	112,000	29,099	[illegible]	34,270
Ferreira Deep	22,500	7,457	32,000	10,290
Geduld	40,000	14,058	45,000	15,359
Geldenhuis Deep	39,760	10,804	[illegible]	12,781
Glynn's Lydenburg	5,560	£5,560‡	3,277	[illegible]
Goch	12,000	[illegible]	16,600	£20,284†
Government G.M. Areas	111,500	[illegible]	136,000	[illegible]
Kleinfontein	43,800	11,723	48,000	13,297
Knight's Central	21,300	5,469	25,800	6,178
Langlaagte Estate	27,100	[illegible]	40,000	£62,290†
Luipaard's Vlei	14,360	[illegible]	16,000	£18,456†
Meyer & Charlton	9,700	£31,540†	14,300	[illegible]
Modderfontein	[illegible]	39,580	92,000	43,114
Modderfontein B	50,000	25,324	57,000	29,200
Modderfontein Deep	39,400	21,656	42,700	22,809
Modderfontein East	25,000	[illegible]	26,000	10,430
New Unified	9,300	£10,762†	10,900	[illegible]
Nourse	35,600	11,678	42,000	13,253
Primrose	20,300	£22,328†	21,700	[illegible]
Randfontein Central	100,500	£162,605†	120,000	£187,469†
Robinson	26,700	5,769	39,800	7,814
Robinson Deep	39,200	12,208	60,100	17,279
Roodepoort United	22,000	£22,224†	23,000	[illegible]
Rose Deep	47,500	10,748	53,300	12,871
Simmer & Jack	53,200	12,657	61,100	13,540
Springs	29,500	12,843	42,000	18,776
Sub Nigel	9,500	5,066	9,900	5,557
Transvaal G.M. Estates	14,835	£26,129‡	13,945	[illegible]
Van Ryn	28,100	[illegible]	31,100	[illegible]
Van Ryn Deep	[illegible]	£127,877†	[illegible]	£138,977†
Village Deep	43,300	[illegible]	48,700	14,643
West Rand Consolidated	30,100	[illegible]	32,300	£48,892†
Witwatersrand (Knights)	28,500	[illegible]	32,000	£47,940†
Witwatersrand Deep	32,060	£49,205†	37,665	[illegible]
Wolhuter	23,600	5,928	32,200	8,291

* Returns not yet received. † £5. 3s. 9d. per oz. ‡ £5. 2s. 9d. per oz

West African Gold Outputs.

	February Treated	February Value	March Treated	March Value
	Tons	Oz.	Tons	Oz.
Abbontiakoon	6,057	[illegible]*	6,709	[illegible]*
Abosso	4,240	1,696	5,000	1,996
Akoko	—	—		
Ashanti Goldfields	4,603	5,059	4,837	[illegible]
Obbuassi	662	£2,414†	[illegible]	£2,480†
Prestea Block A	6,923	£12,914*	6,705	£16,094†
Taquah	2,500	1,627	2,300	1,222

* At par. † Including premium.

Rhodesian Gold Outputs.

	February Treated	February Oz.	March Treated	March Oz.
	Tons		Tons	
Cam & Motor	8,200	1,495	10,052	2,666*
Falcon	15,103	[illegible]	15,405	2,937
Gaika	3,211	1,356	1,204	608
Globe & Phœnix	5,364	6,319		
Jumbo	[illegible]	343	1,450	441
London & Rhodesian	[illegible]	[illegible]	2,308	[illegible]
Lonely Reef	4,900	4,776	1,690	1,669
Planet-Arcturus	5,470	2,662	[illegible]	1,065
Rezende	5,100	2,466	2,400	1,635
Rhodesia G.M. & I.	509	194	597	215
Shamva	25,500	£17,795‡	16,150	£14,695‡
Transvaal & Rhodesian	1,450	£5,116†	1,700	£5,028†

* Also 250 tons copper. † At par. ‡ Gold at £5 per oz. ‖ Also 251 tons copper.

WEST AUSTRALIAN GOLD STATISTICS.—Par Values

	Reported for Export oz.	Delivered to Mint oz.	Total oz.	Total value £
January, 1920	836	25,670	26,506	112,590
February	1,928	49,453	51,381	218,251
March	—	54,020	54,020	229,461
April	835	56,256	57,091	242,506
May	227	50,976	51,203	217,495
June	502	56,679	57,181	242,638
July		48,341	48,341	205,340
August	167	54,258	54,425	231,185
September	141	54,940	55,081	233,963
October	174	53,801	53,975	229 275
November	128	54,729	54,857	233,017
December	321	53,595	53,916	229,057
January, 1921	523	50,934	51,457	218,574
February	684	26,872	27,556	117,050
March	10	47,875	47,885	203,401
April	607	46,602	47,209	200,635

AUSTRALIAN GOLD RETURNS.

	VICTORIA.		QUEENSLAND.		NEW SOUTH WALES	
	1920	1921	1919	1920	1920	1921
	Oz.	Oz.	£	Oz.	£	£
January	7,105	4,587	37,100	4,724	28,000	20,463
February	8,677		43,330	7,200	15,000	21,575
March	24,126		48,000	6,973	22,000	24,344
April	6,368	—	61,200	8,368	12,000	-
May	13,263		38,200	8,432	13,800	
June	15,707	-	44,600	13,725	8,700	—
July	12,782	—	42,060	9,596	17,410	—
August	12,809	—	49,700	9,973	17,168	—
September	13,973	—	37,120	11,789	13,872	—
October	13,432	—	36,100	9,300	24,752	-
November	9,245		32,720	10 200	16,907	-
December	15,305		44,500	12,874	18,137	
Total	152,792	4,587	514,630	114,181	207,746	66,382

AUSTRALASIAN GOLD OUTPUTS.

	February		March	
	Treated Tons	Value £	Treated Tons	Value £
Associated G.M. (W.A.)	5,355	7,601‖	5,977	7,964
Blackwater (N.Z.)	2,710	4,732	2,956	5,742*
Bullfinch (W.A.)	4,550	5,377	—	—
Golden Horseshoe (W.A.)	9,084	4,669‡	9,936	5,183‡
Great Boulder Pro. (W.A.)	8,080	25,048‖	8,585	24,800
Ivanhoe (W.A.)	13,705	5,029‡	14,973	6,?30‡
Kalgurli (W.A.)	4,703	7,261‖	4,280	9,691‖
Lake View & Star (W.A.)	7,344	9,969†	7,067	14,521†
Menzies Con. (W.A.)	1,360	2,604*	1,350	2,415*
Mount Boppy (N.S.W.)	5,751	1,393‡	5,590	1,089‡
Oroya Links (W.A.)	2,063	11,660†	1,490	8,409‖
Progress (N.Z.)	-	—		
Sons of Gwalia (W.A.)	—	—	-	
South Kalgurli (W.A.)	8,830	17,830	7,216	12,188‖
Waihi (N.Z.)	12,830	3,472‡ 20,971§	12,204	3,056‡ 23,304§
Waihi Grand Junc'n (N.Z.)	**10 710	3,119‡ 13,690§	5,780	2,039‡ 8,354§
Yuanmi (W.A.)	1,063	3,423*	1,200	£4,342*

† Including royalties; ‡ Oz. gold.; § Oz. silver; ‖ At par;
* Including premium. ** 7 weeks.

MISCELLANEOUS GOLD AND SILVER OUTPUTS.

	February		March	
	Treated Tons	Value £	Treated Tons	Value £
Brit. Plat. & Gold (C'lbia)	—	229§	—	166§
El Oro (Mexico)	28,250	201,000†	29,500	202,000†
Esperanza (Mexico)	—	5,133††	—	308†‡
Frontino & Bolivia (C'lbia)	2,680	8,268	2,450	7,624
Mexico El Oro (Mexico)	9,425	158,980†	11,340	186,960†
Mining Corp. of Canada	—	60,070*	—	—
Oriental Cons. (Korea)	—	92,500†	—	108,500†
Ouro Preto (Brazil)	6,300	2,076‖	7,200	2,272‖
Plymouth Cons. (Calif'rnia)	8,100	10,374	10,000	11,345
St. John del Rey (Brazil)	—	38,300	—	38,000
Santa Gertrudis (Mexico)	32,407	1,233‡	37,754	9,098‡
Tolima (Colombia)	60**	—	55**	—
Tomboy (Colorado)	14,000	56,000†	15,600	59,000†

† U.S. Dollars. ‡ Profit, gold and silver. ‖ Oz. gold. * Oz. silver. § Oz. platinum and gold. ** Production of silver ore. †† Dollars, loss.

Pato (Colombia): 17 days to April 2, $30,045 from 53,829 cu. yd. 16 days to April 18, $36,295.

PRODUCTION OF GOLD IN INDIA.

	1917	1918	1919	1920	1921
	oz.	oz.	oz.	oz.	oz.
January	44,718	41,420	38,184	39,073	34,028
February	42,566	40,787	36,834	38,872	32,529
March	44,617	41,719	38,317	38,760	32,576
April	43,726	41,504	38,248	37,307	—
May	42,901	40,889	38,608	38,191	-
June	42,924	41,264	38,359	37,864	—
July	42,273	40,229	38,549	37,129	
August	42 591	40,496	37,850	37,375	
September	43,207	40,088	36,813	35,497	
October	43,041	39,472	37,138	35,023	
November	42,915	36,984	39,628	34,522	
December	44,883	40,149	42,643	34,919	—
Total	520,362	485,236	461,171	444,532	99,133

INDIAN GOLD OUTPUTS.

	February		March	
	Tons Treated	Fine Ounces	Tons Treated	Fine Ounces
Balaghat	3,000	2,220	3,250	2,324
Champion Reef	10,831	4,561	11,710	4,407
Mysore	15,950	11,563	15,573	11,285
North Anantapur	700	917	700	908
Nundydroog	8,324	4,901	8,952	5,204
Ooregum	12,500	8,367	12,900	8,448

BASE METAL OUTPUTS.

		Feb.	Mar.
Arizona Copper	Short tons copper	1,000	1,000
British Broken Hill	Tons lead conc.	—	-
	Tons zinc conc.	—	
	Tons carbonate ore.		
Broken Hill Prop.	Tons lead conc.		
	Tons zinc conc.	-	
Broken Hill South	Tons lead conc.	2,770	697
Burma Corp.	Tons refined lead	2,601	3,020
	Oz. refined silver	231,664	245,962
Fremantle Trading	Long tons lead	370	418
Hampden Cloncurry	Tons copper	—	—
	Oz. gold	—	
Kafue Copper	Short tons copper	—	
Mount Lyell	Tons copper	406	512
	Oz. silver	12,816	15,413
	Oz. gold	409	389
Mount Morgan	Tons copper	975†	
	Oz. gold	13,025†	
North Broken Hill	Tons lead		
	Oz. silver	-	
Pilbara Copper	Tons ore	203	—
Poderosa	Tons copper ore	420	300
Rhodesian Broken Hill	Tons lead	1,215	1,630
S'th American Copper	Tons cop. ore ship'd.	—	
Sulphide Corporation	Tons lead conc.	1,811	1,868
	Tons zinc conc.	2,990	2,850
Tanganyika	Long tons copper	1,467	
Zinc Corp.	Tons zinc conc.	7,650	8,740
	Tons lead conc.	552	71

† 8 weeks to March 20.

IMPORTS OF ORES, METALS, ETC., INTO UNITED KINGDOM

		Feb., 1921	Mar., 1921.
Iron Ore	Tons	283,839	257,324
Manganese Ore	Tons	35,193	20,987
Copper and Iron Pyrites	Tons	40,719	38,166
Copper Ore, Matte, and Precipitate	Tons	3,555	932
Copper Metal	Tons	7,186	12,483
Tin Concentrate	Tons	2,546	2,255
Tin Metal	Tons	1,581	576
Lead, Pig and Sheet	Tons	14,684	12,560
Zinc (Spelter)	Tons	4,319	5,803
Quicksilver	Lb.	16,982	378,750
Zinc Oxide	Tons	239	342
White Lead	Cwt.	5,939	4,889
Barytes, ground	Cwt.	22,646	18,588
Phosphate	Tons	37,465	25,726
Sulphur	Tons	—	6,435
Borax	Cwt.	960	1,059
Other Boron Compounds	Tons	1,428	3,448
Nitrate of Soda	Cwt.	133,664	58,079
Nitrate of Potash	Cwt.	7,525	12,716
Petroleum:			
Crude	Gallons	920,111	
Lamp Oil	Gallons	14,621,854	11,603,953
Motor Spirit	Gallons	13,775,416	23,056,848
Lubricating Oil	Gallons	3,392,702	3,844,085
Gas Oil	Gallons	3,193,753	4,282,603
Fuel Oil	Gallons	33,515,259	41,148,617
Total Petroleum	Gallons	69,420,821	83,938,899

Outputs of Tin Mining Companies.

In Tons of Concentrate.

	Jan. Tons	Feb. Tons	Mar. Tons
Nigeria			
Associated Nigerian	7	7	
Bisichi	25	26	22
Bongwelli	5		
Champion (Nigeria)			
Dua	2	1½	½
Ex-Lands	30	20	20
Filani	4	3½	
Gold Coast Consolidated		2	3
Gurum River	11	12	13
Jantar	–		
Jos		15	16
Kaduna	14	14½	
Kaduna Prospectors	6	8½	14
Kano	½	4	3
Lower Bisichi	7¼	5¼	6½
Lucky Chance		–	
Minna	1	1½	3
Mongu	51	60	53
Naraguta	35		70
Naraguta Extended	10	10	8
Nigerian Consolidated	17	24	20
N. N. Bauchi	40	40	45
Ofin River			
Rayfield	45	30	28
Ropp	86	82	97
Rukuba	4		4½
South Bukeru	18		
Sybu	1	¾	¼
Tin Fields	4	4	6
Yarde Kerri	5½	7	13
Federated Malay States:			
Chenderiang		–	81*
Gopeng	72	66	72
Idris Hydraulic		21	21
Ipoh	19¼	15½	17½
Kamunting		–	122*
Kinta	31¼	28¼	30
Lahat	68¼	56½	57
Malayan Tin	80½	80½	95¼
Pahang	166	136	213
Rambutan	16½	15	15
Sungei Besi	33	35	42
Tekka	25½	29	30
Tekka-Taiping	21	15	13¼
Tronoh	36	19	20
Cornwall			
East Pool	95†	–	–
Geevor	–	–	
South Crofty	55†	–	
Other Countries:			
Aramayo Francke (Bolivia)	157	130	200
Berenguela (Bolivia)	24	26	31
Briseis (Tasmania)	11	8	8
Deebook Ronpibon (Siam)	20	16	30½
Leeuwpoort (Transvaal)	–		99
Macready (Swaziland)	–	–	19
Renong (Siam)	90	31½	21
Rooiberg Minerals (Transvaal)	45	45	50
Siamese Tin (Siam)	83	50	57
Tongkah Harbour (Siam)	67	33	37
Zaaiplaats (Transvaal)	21	13	–

* Three months. † Tin and wolfram

Nigerian Tin Production.

In long tons of concentrate of unspecified content

Note. These figures are taken from the monthly returns made by individual companies reporting in London and probably represent 85% of the actual outputs.

	1916	1917	1918	1919	1920	1921
	Tons	Tons	Tons	Tons	Tons	Tons
January	531	667	678	613	547	438
February	528	646	668	623	477	370
March	547	655	707	606	505	445
April	486	555	584	546	467	—
May	536	509	525	483	383	—
June	510	473	492	484	435	—
July	506	479	545	481	484	—
August	498	551	571	616	447	—
September	535	538	520	561	528	—
October	584	578	491	625	628	—
November	679	621	472	536	544	—
December	654	655	518	511	577	—
Total	6 594	6.927	6,771	6,685	6,022	1,253

Production of Tin in Federated Malay States.

Estimated at 70% of Concentrate shipped to Smelters. Long Tons.

	1917	1918	1919	1920	1921
	Tons	Tons	Tons	Tons	Tons
January	3,558	3,030	3,765	4,265	3,298
February	2,755	3,197	2,734	3,014	3,111
March	3,286	2,609	2,819	2,770	2,190
April	3,251	3,308	2,858	2,606	—
May	3,413	3,332	3,407	2,741	—
June	3,489	3,070	2,877	2,940	—
July	3,253	3,373	3,756	2,824	—
August	3,413	3,259	2,956	2,786	—
September	3,154	3,157	3,161	2,734	—
October	3,436	2,870	3,221	2,837	—
November	3,300	3,132	2,972	2,573	—
December	3,525	3,022	2,409	2,838	—
	39,833	37,370	36,935	34,928	8,599

Stocks of Tin.

Reported by A. Strauss & Co. Long Tons.

	Feb. 28	Mar. 31	April 30
Straits and Australian Spot	2,128	1,738	1,357
Ditto, Landing and in Transit	10	80	185
Other Standard, Spot and Landing	5,365	5,456	5,081
Straits, Afloat	40	385	775
Australian, Afloat	295	200	150
Banca, in Holland	3,187	2,974	2,867
Ditto, Afloat	209	—	200
Billiton, Spot	755	579	534
Billiton, Afloat	—	—	—
Straits, Spot in Holland and Hamburg	—	—	–
Ditto, Afloat to Continent	—	95	100
Total Afloat for United States	1,385	781	1,441
Stock in America	3,546	3,476	2,441
Total	16,900	15,764	15,131

Shipments, Imports, Supply, and Consumption of Tin.

Reported by A. Strauss & Co. Long tons.

	Feb.	Mar.	April
Shipments from:			
Straits to U.K.	20	395	775
Straits to America	220	395	925
Straits to Continent	—	125	100
Straits to Other Places	33	289	825
Australia to U.K.	100	50	—
U.K. to America	715	100	295
Imports of Bolivian Tin into Europe	800	366	811
Supply:			
Straits	240	915	1,800
Australian	100	50	—
Billiton	—		—
Banca	—	79	70*
Standard	1,561	1,290	865
Total	1,961	2,334	2,735
Consumption:			
U.K. Deliveries	1,321	1,359	1,531
Dutch "	164	389	152
American	1,585	1,683	1,590
Straits, Banca & Billiton, Continental Ports, etc.	35	39	95
Total	3,568	3,470	3,368

* To March 31 only.

OUTPUTS REPORTED BY OIL-PRODUCING COMPANIES.

		Feb.	March
Anglo-Egyptian	Tons	16,991	13,627
Anglo-United	Barrels	9,219	8,900
Apex Trinidad	Barrels	—	43,525
British Burmah	Barrels	56,023	65,768
Caltex	Barrels	78,962	92,820
Dacia Romana	Tons	251	—
Kern River	Barrels	95,010	105,220
Lobitos	Tons	7,659	8,389
Roumanian Consol.	Tons	1,282	1,375
Santa Maria	Tons	1,000	1,300
Steaua Romana	Tons	14,991	17,910
Trinidad Leaseholds	Tons	11,400	13,400
United of Trinidad	Tons	3,767	3,698

QUOTATIONS OF OIL COMPANIES' SHARES.

Denomination of Shares £1 unless otherwise noted.

	April 7, 1921 £ s. d.	May 5, 1921 £ s. d.
Anglo-American	4 7 6	5 0 0
Anglo-Egyptian B.	1 17 6	2 0 0
Anglo-Persian 1st Pref.	1 2 0	1 2 6
Anglo-United, Wyoming	10 0	10 0
Apex Trinidad	2 10 0	2 10 0
British Borneo (10s.)	15 0	17 6
British Burmah (8s.)	17 6	1 1 3
Burmah Oil	6 17 6	7 15 0
Caltex ($1)	7 6	6 6
Dacia Romano	17 6	1 0 0
Kern River, Cal. (10s.)	1 2 0	1 2 6
Lobitos, Peru	3 17 6	4 5 0
Mexican Eagle, Ord. ($10)	5 7 6	6 12 6
,, ,, Pref. ($10)	5 5 0	6 7 6
North Caucasian (10s.)	12 6	17 6
Phœnix, Roumania	12 0	12 6
Roumanian Consolidated	12 6	14 3
Royal Dutch (100 gulden)	44 0 0	52 0 0
Scottish American	15 0	12 6
Shell Transport, Ord.	5 0 0	6 2 6
,, ,, Pref. (£10)	8 0 0	8 5 0
Steaua Romana	14 3	16 3
Trinidad Central	3 5 0	4 12 6
Trinidad Leaseholds	2 5 0	2 12 6
United British of Trinidad	17 6	1 2 6
Ural Caspian	13 9	1 0 0
Uroz Oilfields (10s.)	8 9	8 9

DIVIDENDS DECLARED BY MINING COMPANIES.

Date	Company	Par Value of Shares	Amount of Dividend
April 18	Broken Hill Proprietary	£1.	9d. less tax
April 16	Gold Coast Amal.	£1.	2s. less tax
April 16	Gold Fields Rhodesian	10s.	6d. less tax
May 7	Lake View Investment	10s.	5% less tax
April 21	Premier Diamond	Pref. 5s.	125% less tax
May 7	Scottish Australian Mining	£1.	7½% less tax
May 2	Tekka-Taiping	£1.	3d. less tax
April 23	Waihi Gold	10s.	6d. tax paid
May 7	Wankie Colliery	10s.	5% less tax
April 21	Wolhuter	£1.	9d. less tax

PRICES OF CHEMICALS. May 9.

These quotations are not absolute; they vary according to quantities required and contracts running.

		£ s. d.
Acetic Acid, 40%	per cwt.	1 3 0
,, 80%	,,	2 6 0
,, Glacial	,,	2 16 0
Alum	per ton	18 0 0
Alumina, Sulphate of	,,	16 0 0
Ammonia, Anhydrous	per lb.	2 6
,, 0.880 solution	per ton	45 0 0
,, Carbonate	per lb.	4
,, Chloride of, grey	per ton	45 0 0
,, ,, ,, pure	per cwt.	3 15 0
,, Nitrate of	per ton	50 0 0
,, Phosphate of	,,	75 0 0
,, Sulphate of	,,	24 0 0
Antimony, Tartar Emetic	per lb.	2 7
,, Sulphide, Golden	,,	1 6
Arsenic, White	per ton	50 0 0
Barium Carbonate	,,	11 0 0
,, Chlorate	per lb.	1 0
,, Chloride	per ton	19 0 0
,, Sulphate	,,	10 0 0
Benzol, 90%	per gal.	3 0
Bisulphate of Carbon	per ton	55 0 0
Bleaching Powder, 35% Cl.	,,	18 0 0
,, Liquor, 7%	,,	7 0 0
Borax	,,	34 0 0
Boric Acid, crystals	,,	69 0 0
Calcium Chloride	,,	10 0 0
Carbolic Acid, crude 60%	per gal.	1 8
,, crystallized, 40°	per lb.	7
China Clay (at Runcorn)	per ton	3 10 0 to 4 10 0
Citric Acid	per lb.	2 3
Copper, Sulphate of	per ton	30 0 0
Cyanide of Sodium, 100%	per lb.	1 0
Hydrofluoric Acid	,,	7½
Iodine	per oz.	1 0
Iron, Nitrate of	per ton	8 0 0
,, Sulphate of	,,	4 0 0
Lead, Acetate of, white	,,	48 0 0
,, Nitrate of	,,	48 0 0
,, Oxide of, Litharge	,,	38 0 0
,, White	,,	40 0 0
Lime, Acetate, brown	,,	9 0 0
,, ,, grey 80%	,,	13 0 0
Magnesite, Calcined	,,	21 0 0
Magnesium, Chloride	,,	12 0 0
,, Sulphate	,,	10 0 0
Methylated Spirit 64° Industrial	per gal.	6 9
Nitric Acid, 80° Tw.	per ton	32 0 0
Oxalic Acid	per lb.	0 11
Phosphoric Acid	per ton	50 0 0
Potassium Bichromate	per lb.	11
,, Carbonate 85%	per ton	45 0 0
,, Chlorate	per lb.	0 6
,, Chloride 80%	per ton	21 0 0
,, Hydrate (Caustic) 90%	,,	47 0 0
,, Nitrate	,,	55 0 0
,, Permanganate	per lb.	1 9
,, Prussiate, Yellow	,,	1 4
,, ,, Red	,,	2 3
,, Sulphate, 90%	per ton	20 0 0
Sodium Metal	per lb.	1 3
,, Acetate	per ton	26 0 0
,, Arsenate 45%	,,	45 0 0
,, Bicarbonate	,,	12 0 0
,, Bichromate	per lb.	8
,, Carbonate (Soda Ash)	per ton	15 0 0
,, ,, (Crystals)	,,	7 0 0
,, Chlorate	per lb.	4½
,, Hydrate, 76%	per ton	27 0 0
,, Hyposulphite	,,	20 0 0
,, Nitrate, 95%	,,	21 0 0
,, Phosphate	,,	25 0 0
,, Prussiate	per lb.	8
,, Silicate	per ton	11 0 0
,, Sulphate (Salt-cake)	,,	8 0 0
,, ,, (Glauber's Salts)	,,	7 0 0
,, Sulphide	,,	25 0 0
,, Sulphite	,,	13 0 0
Sulphur, Roll	,,	12 10 0
,, Flowers	,,	13 10 0
Sulphuric Acid, Fuming, 65°	,,	24 0 0
,, ,, free from Arsenic, 144°	,,	6 5 0
Superphosphate of Lime, 30%	,,	8 10 0
Tartaric Acid	per lb.	1 7
Turpentine	per cwt.	3 8 6
Tin Crystals	per lb.	1 7
Titanous Chloride	,,	1 0
Zinc Chloride	per ton	23 0 0
Zinc Sulphate	,,	19 0 0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS:	May 5, 1920 £ s. d.	May 5, 1921 £ s. d.
RAND:		
Brakpan	1 17 6	1 12 6
Central Mining (£8)	8 15 0	6 5 0
City & Suburban (£4)	[illegible]	[illegible]
City Deep	1 3	8
Consolidated Gold Fields	1 1	18
Consolidated Langlaagte	1 1	10 0
Consolidated Main Reef	15	[illegible]
Consolidated Mines Selection (10s.)	1 [illegible]	[illegible]
Crown Mines (10s.)	1 6	2 [illegible]
Daggafontein	18	[illegible]
Durban Roodepoort Deep	7 6	4 0
East Rand Proprietary	[illegible]	4
Ferreira Deep	11 6	6
Geduld	[illegible]	2 7 6
Geldenhuis Deep	8 0	5 0
Gov't Gold Mining Areas	4 6	0 0
Johannesburg Consolidated	1	1 4 0
Jupiter	6	4 0
Kleinfontein	9	5
Knight Central	0	4 3
Knights Deep	7 6	15 0
Langlaagte Estate	15 6	11
Meyer & Charlton	4 10 0	4 2 6
Modderfontein (£10)	3 1 0	3 5 0
Modderfontein B (5s.)	10 0	1 3 9
Modderfontein Deep (5s.)	2 7 6	2 5 0
Modderfontein East	1 0	11 3
New State Areas	1 8 9	1 3 9
Nourse	10 6	6 9
Rand Mines (5s.)	1 18 9	2 [illegible] 0
Rand Selection Corporation	3 18 9	2 17 6
Randfontein Central	16 0	9 6
Robinson (£5)	0	9 6
Robinson Deep A (1s.)	1 0 0	11 3
Rose Deep	16	12 3
Simmer & Jack	5 0	6
Springs	2 6	1 15 0
Sub Nigel	15 0	12 6
Union Corporation (12s. 6d.)	1 1 6	16
Van Ryn	17 6	11 0
Van Ryn Deep	3 7 6	3 12 6
Village Deep	11 0	6
West Springs	18 9	1 6
Witwatersrand (Knight's)	16	13 9
Witwatersrand Deep	9 0	6 6
Wolhuter	5 9	4 6
OTHER TRANSVAAL GOLD MINES:		
Glynn's Lydenburg	13	6 6
Sheba (5s.)	1	1 6
Transvaal Gold Mining Estates	13	7 0
DIAMONDS IN SOUTH AFRICA:		
De Beers Deferred (£2 10s.)	24 15 0	11 10 0
Jagersfontein	4 17 6	5 0
Premier Deferred (2s. 6d.)	11 5 0	4 10 0
RHODESIA:		
Cam & Motor	11 0	6
Chartered British South Africa	18 6	12 0
Falcon	10 6	4 0
Gaika	12 6	5 3
Globe & Phoenix (5s.)	14 6	17 6
Lonely Reef	3 0 0	2 0 0
Rezende	5 0 0	3 0 0
Shamva	1 15 0	1 10 0
Willoughby's (10s.)	5 6	4 9
WEST AFRICA:		
Abbontiakoon (10s.)	3	2 0
Abosso	11 0	8 0
Ashanti (4s.)	19 0	13 6
Prestea Block A	3 3	2 0
Taquah	15 0	8 0
WEST AUSTRALIA:		
Associated Gold Mines	6	[illegible]
Associated Northern Blocks	0	6
Bullfinch	6 0	1 0
Golden Horse Shoe (£5)	18 9	10 0
Great Boulder Proprietary (2s.)	8 6	5 0
Great Fingall (10s.)	2 6	1 6
Hampton Properties	1 5 0	6 3
Ivanhoe (£5)	1 10 0	17 6
Kalgurli	12 0	10 3
Lake View Investment (10s.)	17 0	10 0
Sons of Gwalia	6 9	5 0
South Kalgurli (10s.)	7 3	6 6

GOLD, SILVER, cont.	May 5, 1920 £ s. d.	May 5, 1921 £ s. d.
OTHERS IN AUSTRALASIA:		
Blackwater, New Zealand	[illegible]	[illegible]
Consolidated G. F. of New Zealand	[illegible]	[illegible]
Mount Boppy, N.S.W. (10s.)	1 0	[illegible]
Progress, New Zealand	1 0	1
Waihi, New Zealand	[illegible]	1 [illegible]
Waihi Grand Junction, New Zealand	[illegible]	[illegible]
AMERICA:		
Buena Tierra, Mexico	1	[illegible]
Camp Bird, Colorado	1	[illegible]
El Oro, Mexico	1 6	1
Esperanza, Mexico	1 0	1
Frontino & Bolivia, Colombia	1 6	[illegible]
Le Roi No. 2 (£5), British Columbia	10 0	6
Mexico Mines of El Oro, Mexico	6 10	[illegible]
Nechi (pref. 10s.), Colombia	10 0	[illegible]
Oroville Dredging, Colombia	1 3 9	1 5
Plymouth Consolidated, California	18 9	17
St. John del Rey, Brazil	16 6	15 6
Santa Gertrudis, Mexico	1 9	6
Tomboy, Colorado	12	[illegible]
RUSSIA:		
Lena Goldfields	1 5 0	11
Orsk Priority	17 6	10 0
INDIA:		
Balaghat (10s.)	8	6
Champion Reef (2s. 6d.)	3 6	0
Mysore (10s.)	1 1 3	1 6
North Anantapur	4 0	[illegible]
Nundydroog (10s.)	1	6
Ooregum (10s.)	6	1 6

COPPER:

	May 5, 1920	May 5, 1921
Arizona Copper (5s.), Arizona	1 12 6	1 5 0
Cape Copper (£2), Cape and India	1 7 6	15 0
Esperanza, Spain	[illegible]	5 0
Hampden Cloncurry, Queensland	15 0	5 0
Mason & Barry, Portugal	2 10 0	1 15 0
Messina (5s.), Transvaal	5 6	4 0
Mount Elliott (£5), Queensland	2 10 0	10 0
Mount Lyell, Tasmania	1 0	13 0
Mount Morgan, Queensland	1 2 6	10 0
Namaqua (£2), Cape Province	1 10 0	15 0
Rio Tinto (£5), Spain	35 0 0	30 0 0
Russo-Asiatic Consd., Russia	12 0	8 6
Sissert, Russia	12 6	7 3
Spassky, Russia	1 0 0	10 0
Tanganyika, Congo and Rhodesia	2 1	1 5 9

LEAD-ZINC:

	May 5, 1920	May 5, 1921
BROKEN HILL:		
Amalgamated Zinc	1 7 6	17 0
British Broken Hill	2 0 6	16
Broken Hill Proprietary	3 0 0	1 15 0
Broken Hill Block 10 (£10)	1 6 3	10 0
Broken Hill North	2 13	1 2 6
Broken Hill South	2 15 0	*1 5 0
Sulphide Corporation (15s.)	16	10
Zinc Corporation (10s.)	1	8
ASIA:		
Burma Corporation (10 rupees)	10 0 0	7 6†
Russian Mining	11	7
RHODESIA:		
Rhodesia Broken Hill (5s.)	15 0	7 6

TIN:

	May 5, 1920	May 5, 1921
Aramayo Francke, Bolivia	4 12 6	2
Bisichi, Nigeria	14 0	9
Briseis, Tasmania	5 3	2
Dolcoath, Cornwall	5 6	6
East Pool (5s.) Cornwall	11 3	4
Ex-Lands Nigeria (2s.), Nigeria	3 9	1 6
Geevor (10s.) Cornwall	16 3	3 9
Gopeng, Malay	2 2 6	1 10 0
Ipoh Dredging, Malay	1 0 0	10 0
Kamunting, Malay	2 10 0	1 7 6
Kinta, Malay	2 16 3	1 10 0
Malayan Tin Dredging, Malay	2 5 0	1 7 6
Mongu (10s.), Nigeria	1 2 6	10
Naraguta, Nigeria	15 0	15 0
N. N. Bauchi, Nigeria (10s.)	6 9	2 6
Pahang Consolidated (5s.), Malay	12 0	6 6
Rayfield, Nigeria	11 6	5 3
Renong Dredging, Siam	5 0	1 7 6
Ropp (4s.), Nigeria	11 6	6 9
Siamese Tin, Siam	4 7 6	2 2 6
South Crofty (5s.), Cornwall	13 9	6 6
Tehidy Minerals, Cornwall	1 3 9	8 9
Tekka, Malay	5 10 0	18 9
Tekka-Taiping, Malay	1 8 0	1 0 0
Tronoh, Malay	2 3 9	1 5 0

† 10-rupee shares of Indian Co.

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also notices of new books and pamphlets, lists of patents on mining and metallurgical subjects, and abstracts of the yearly reports of mining companies.

ANACONDA ELECTROLYTIC ZINC.

A paper by Frederick Laist and others was presented at the February meeting of the American Institute of Mining and Metallurgical Engineers describing the electrolytic zinc plant of the Anaconda Copper Mining Company, Montana. The zinc ores at this company's group of mines are complex sulphides, and the concentrates average only 35% zinc and are high in iron and lead. After trying the Horwood preferential flotation process for the improvement of these concentrates with discouraging results it was decided to try roasting, leaching with sulphuric acid, and electrolysis of sulphate solutions. The paper is of considerable length and contains many graphs, plans, and photos; we are able only to give an outline of the main points of the process.

Experiments.—The authors, in the first section of the paper, give an account of the facts as ascertained in laboratory examination of the proposed method. They soon found, as had other investigators, that the only way to obtain a good zinc deposit is to have the electrolyte free from all metals more electro-negative than zinc, such as copper, cadmium, lead, arsenic, antimony, etc. Arsenic and antimony are particularly injurious, causing very poor current efficiency and small yield per horse-power when present even in amounts so small as almost to defy detection, 1 mg. or less per litre. A pure zinc is soluble only with difficulty in sulphuric acid; an impure zinc dissolves very readily. Electrolytic zinc deposited from pure solutions is, of course, extremely pure and dissolves only about one-fiftieth as rapidly as ordinary zinc. The dissolving of pure zinc in dilute sulphuric acid can be greatly accelerated by the addition of a few drops of a solution containing copper or arsenic. The presence of these metals in the solution going to the electrolytic cells would have the same effect on the zinc deposit at the cathodes, so that re-solution would set in and might proceed at a rate that would entirely offset the depositing power of the current. In such a case no zinc would result from the passage of the current, and nothing but hydrogen would be made at the cathode and oxygen at the anode. Smaller amounts of impurities would result in the zinc being redissolved, but more slowly than it is deposited, producing cathodes full of holes of various sizes, while the yield per horse-power-day would be proportionally decreased. H. W. Gepp, in experimenting at Bully Hill, California, found that one of the most injurious impurities present in those ores was cobalt. According to him fifteen parts of cobalt per million parts of solution is fatal to electrolysis. The cell work is seriously impaired with only ten parts per million. The cobalt may be precipitated with manganese by the addition of permanganate or it may be thrown down in the presence of manganese by the addition of beta-naphthol and sodium nitrite, also by zinc dust from the neutral solution in the presence of ferric iron, copper, and arsenic. It was not found difficult to maintain an extremely high degree of purity in the zinc solution going to the cells if the iron in the solution was thoroughly oxidized, before being precipitated, by means of limestone or excess calcine, and if sufficient zinc dust was added to satisfy fully the copper, cadmium, and whatever small amount of lead might be present. If the ore contains very little iron, in proportion to its arsenic content, it might be necessary to add iron in the form of ferric salt in order to ensure the complete precipitation of all arsenic as ferric arsenate. It was found that the best way to make sure of the oxidation of the iron was to maintain a small amount of manganese in solution. Manganese becomes oxidized in passing through the cells, forming permanganic acid, manganic sulphate, and manganese dioxide. The ores contain sufficient manganese for this purpose, so that it is seldom necessary to provide outside manganese. It is possible to ensure oxidation of the iron by other means, notably continued air agitation in the presence of milk of lime. An aluminium plate made the most suitable cathode and a lead plate the most suitable anode. The latter quickly becomes coated with a brown layer of manganese dioxide and lead peroxide, and if the zinc solution is entirely free from chlorides the lead is not attacked. Some of the lead anodes have been used for three years and seem to be just as good as when put in. In the beginning it was the intention to use aluminium plates only for building up starting sheets of suitable weight. This, however, proved unsatisfactory, as the starting sheets tended to warp and cause short circuits. Aluminium cathodes are therefore used in all of the cells, and the zinc is allowed to deposit until a sheet of sufficient weight is built up to go directly to the casting furnace. Generally 48-hr. sheets, which weigh about 20 lb., are made, so that about 40 lb. of zinc is stripped each time the cathode is withdrawn. In order to avoid re-solution, good contact must be maintained between the zinc and the aluminium plate. The plate, therefore, must be roughened sufficiently to ensure adherence as the zinc sheet becomes heavier. This limits the weight of zinc sheets it is possible to build up, and this, together with the tendency toward sprouting, limits practice to 48-hr. deposits. Seventy-two hour sheets have been successfully made, but on the average the 48-hr. plates give the best results. The better current efficiency with the younger deposits more than offsets the labour required for more frequent stripping. The experimental work was done with current densities varying from 10 to 100 amperes per square foot. In practice, the most satisfactory density is from 22 to 25 amperes. It is not necessary to circulate rapidly as, with the current density used, the evolution of gas at the anode is sufficient to provide the necessary agitation.

Roasting.—The authors proceed to detail the steps whereby the process was gradually developed, and then describe the process as established at Great Falls. The plant as finally completed has an output of 150 tons of electrolytic zinc per day. Roasting of the concentrates is done partly at Anaconda, where McDougal furnaces are used, and partly in Wedge furnaces at Great Falls. The following is an average analysis of the concentrate and of the resulting roasted material:

	[illegible]	Roasted Material
[illegible]	[illegible]	[illegible]
Cu	1·8	1·0
Pb	9·5	10·3
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

It was recognized at the beginning that the concentrates must be finely ground to get the maximum solubility; screen analyses of the crushed concentrates show that 67% goes through minus 200 mesh. A low initial temperature of the roast gives better solubilities on concentrates containing appreciable amounts of lead and iron sulphides. Lead, if 5% or more is present, tends to cause the roasting concentrate to sinter and ball up at the higher temperatures; as these agglomerated masses will be insufficiently roasted, poor solubility results, and a larger amount of classifier sand is produced in the leaching plant. The aim is to prevent simultaneous oxidation of the iron and zinc, as far as possible, by keeping the temperature of the two top roasting hearths below the active break-up temperature of zinc sulphide and yet high enough to permit FeS_2 and FeS to oxidize in the time allowed. Unfortunately, zinc sulphide begins to oxidize at the low temperature of the upper hearths but to a less degree than the iron sulphide, and therefore a small amount of ferrate will be formed. If the dross containing a large amount of metallics is fed in with the concentrates, even at the low temperature of the top floors, the formation of ferrates is greatly increased. If the dross is charged to the lower floors, where there is little or no iron sulphide, there is very little formation of ferrates.

The amount of sulphate formed is dependent on a low initial temperature, so that apparently the amount of sulphate formed is largely influenced by the amount of Fe_2O_3 present and the reactions that take place in sulphate-roasting are those of the contact acid process, where freshly prepared ferric oxide is used as a catalyser. The iron sulphide is oxidized to ferric oxide in the top hearths and acts as a catalyser changing the sulphur dioxide from the roasting zinc sulphide to sulphur trioxide which, in turn, combines with the freshly forming zinc oxide to form zinc sulphate. In proof of this, if the temperature at first is high, practically all of the iron will be combined with the zinc to form ferrates, in which case very little sulphate will be formed, although temperatures and sulphur elimination are the same in the lower part of the furnace as when sulphating. The amount of sulphate remaining in the finished calcine is dependent on the end temperature. To decrease the percentage of sulphate and sulphur, it is only necessary to raise the end temperature and break up or prevent the formation of sulphates. While the solubility falls when the sulphates are broken up, it will be better than when ferrates are formed on the top hearths instead of Fe_2O_3.

Leaching.—The leaching is continuous and is carried out in two steps: (1) A neutral leach where all the calcine and approximately one-half of the total acid is added; (2) an acid leach where no calcine and the remainder of the acid is added. The solution for the first, or neutral, leach is made up with one-half of the cell acid (11½% sulphuric acid and 2½% zinc) and the partly spent leach liquor (0·6% sulphuric acid and 10% zinc from the acid leach). This mixture is run into the first of a series of seven continuous-leaching Pachuca tanks. Sufficient iron must be present and oxidized to account for all the arsenic and antimony, otherwise they will not be removed and poor tank-room efficiency will result. Calcine is run into the three succeeding Pachuca tanks in such a manner that there is an average drop of 2½% acid in each tank. Nothing is added to the fifth tank, as it is used as an indicator, or control, tank in which the acid should be nearly, or completely, spent. One-sixth of the total amount of calcine is added to the sixth Pachuca tank, together with a small amount of pulverized limestone. The excess base contained in the calcine and lime rock completely precipitates the ferric iron, granulates the gelatinous silica, and partly precipitates the copper. These chemical precipitates, together with the insoluble residue, carry down the freshly formed insoluble compounds of arsenic and antimony, and completely free the solution from them. For instance, the arsenic may be as high as 2 grams per litre in the liquor of the third Pachuca tank and less than 1 mg. in the seventh Pachuca, which is also a control tank, but its function is mostly physical. After the base is added it takes several minutes for the leach to coagulate. If this step is carried out too rapidly, poor settlement results, and in a short time the rest of the plant will be blocked with mud. When this step is properly carried out, each granular particle of solid appears to be enclosed in a flake of freshly precipitated iron, lime, or gelatinous silica; that is, each solid particle becomes a nucleus about which the chemical precipitate collects and provides the necessary weight to carry down these flaky particles. The capacity of the settling equipment is dependent on the proper handling of the seventh Pachuca. It is easy to control, but requires close attention. The discharge of the last Pachuca goes to the neutral classifiers. These take out the sands, which are re-ground and returned to the system for further treatment. The overflow from the classifier flows to Dorr settlers, which discharge a clear overflow for the purification tanks, and a spigot product, containing 50% solids, which forms the feed to the acid leach.

In this neutral leach, all the calcine enters the process and approximately three-fourths of the soluble zinc is taken into solution; the iron is oxidized and precipitated; gelatinous silica is coagulated by excess base and rendered granular; the arsenic and antimony are completely precipitated; 80% of the copper is precipitated as hydroxide by the excess base, this making possible the cheap removal of most of the copper and supplying the iron for the removal of arsenic and antimony in the acid leach; a large percentage of the zinc is separated from the residues and is contained in a clear settler overflow along with 20% of the soluble copper and all the soluble cadmium which goes to the purification plant, while the settler spigot product containing three parts of solids and two parts of solution is elevated to the acid leach.

The ground neutral classifier sand and the neutral settler spigot product are leached in three 10 by 20 ft. continuous leaching Pachuca tanks with the remainder of the cell acid and sent to the acid settlers. This operation is simple; it is necessary only to see that the overflow from the Pachucas is maintained at approximately ½% acid. Variations of 1% over a considerable time do not materially affect results, but too high an acid for a long period increases the volume of solution, hindering settlement, and causes the iron to circulate, which interferes with the settlement of the neutral side. Too low an acid for a long period results in low recovery due to undissolved ZnO and to high moisture in the filter-cake caused by precipitating ferric hydroxide, gelatinous silica, and alumina without granulating. Poor settling of the acid settlers also results for the same reasons.

The spigot product of the acid settlers, containing

60% solid and 40% moisture, goes by gravity to blanket-covered filters of the Oliver type. The cake from these filters is re-pulped with hot water or hot water and acid, in case there is enough acid-soluble zinc left in the first cake to justify it, and then re-filtered on a second set of blanket-covered Olivers to recover more of the soluble zinc. Hot wash water is used on each set of filters. If this double filtering operation is properly carried out, less than 20% of the zinc contained in the residues will be soluble in dilute sulphuric acid. In other words, if 90% of the zinc in the calcine was soluble, 10% of the total zinc in the calcine would be in the final residue as insoluble zinc and would be 80% of the total zinc in the residue. That is, the recovery would be 87½%. This is considered good practice and easily obtainable on 45% zinc calcine. The filtrate from the acid filters is combined with the acid settler overflow and goes to the copper roughing tanks, where scrap zinc from the tank room and scrap iron are added to rough out the copper. It is then pumped to the first of the neutral leach Pachucas and forms a part of the neutral leach acid.

The results of the acid leaching system are: (1) Solution of the remainder of the acid-soluble zinc and the copper; (2) final separation of the solids from the zinc and copper solutions; (3) roughing out of the copper and chlorine; (4) solution of sufficient iron to guarantee the removal of arsenic and antimony in the neutral leach step; (5) elimination of the arsenic and antimony which are only partly redissolved in dilute acid. About 10% of the arsenic and antimony circulate in the acid Dorr overflow.

Purification of Solutions.—The failure of early experimenters to recognize the harmful effects of minute quantities of certain impurities is the principal reason for their disappointment. It is not safe to say that a definite amount of any impurity such as copper, arsenic, antimony, cobalt, cadmium, tellurium, or selenium can be tolerated because the evil effects of most of these appear to be cumulative. For instance, when a small amount of copper is present (10 mg. per litre), the harmful effect of a little arsenic or antimony is greatly multiplied; therefore the only safe thing is to eliminate all to the greatest possible degree. If the neutral leach is properly carried out, the neutral Dorr overflow will contain, in addition to zinc sulphate, all the soluble cadmium and a certain percentage of the copper; but the arsenic, antimony, ferric iron, and part of the copper will have been precipitated. Final purification with zinc dust will take care of the copper and cadmium and will precipitate a certain amount of any arsenic and antimony that has passed the neutral leach; but it is not safe to depend on zinc dust for arsenic and antimony removal. The Great Falls purification plan is based on the fact that a large excess of zinc dust will completely precipitate the last traces of cadmium and copper; therefore, to get a reasonable efficiency from the zinc dust, a recovery system was installed and later supplemented by a purification slime-treatment plant. Copper is rapidly removed by the zinc dust, but cadmium is removed slowly and with difficulty unless a large excess of zinc dust is used. As cadmium must be reduced to less than 20 mg. per litre in the purified solution, to make grade "A" zinc in the tank room, and as no rapid test of which the authors are aware is sufficiently delicate to indicate that small amount of cadmium, it has been necessary to develop the present practice.

The overflow from the neutral settlers is pumped to twelve 10 by 20 ft. air-agitated Pachuca tanks, where it is treated; first, with recovered zinc sludge from the purification classifiers, to rough out the copper, then with zinc dust, added carefully until copper cannot be detected with the hydrogen-sulphide test. A definite excess of zinc dust is then added to ensure that all cadmium is precipitated. The amount of excess dust added is determined by practice and is varied from day to day by the zinc-plant superintendent after he has received the analyses of the neutral Dorr overflow and the purified solution for the previous day. It is a cut-and-dry method, but is not difficult to control. Like the rest of the process it must be carefully watched because an error here results in poor tank-room efficiency for several days. The best method is to avoid trouble by using plenty of dust. On the other hand, the use of too much dust is expensive, but so long as there is insufficient zinc sludge coming back from the classifiers to rough out the copper too much zinc dust is not being used.

After the addition of the excess zinc dust, the tank is agitated for 15 minutes and then discharged through a drag-line classifier to two 10 by 50 ft. Dorr settlers in parallel, which are in series with six 25 by 65 ft. concrete settling ponds. The ponds are arranged in parallel, so that any one can be cut out for cleaning without interfering with the others, and are 7 ft. deep at the feed end and 2½ ft. at the discharge; the sloping bottom facilitates cleaning. During normal operations one pond is sluiced out per shift; if the sludge is allowed to remain in the bottom of the pond too long, the cadmium oxidizes and goes into solution. Traces of acid or ferric sulphate hasten the re-solution of the cadmium. The pond overflow launder leads to a concrete sump, which supplies the feed to eight Shriver clarifying presses. The purified solution, after passing the presses, is as clear as crystal. If the overflow from the ponds is clear, the presses are probably superfluous, but they act as a safeguard, and all the solution has been forced through them. The clarified solution is pumped to two 12 by 50 ft. storage tanks and forms the feed to the tank room. The sludge from the purification Dorrs and the ponds is pumped to a scavenger Dorr, which receives all the spill and washings from the presses and the purification settling system and acts as a combination settler and slime storage tank for the purification slime treatment plant. The overflow of the scavenger settler is pumped back to the purification tanks. The spigot product of the scavenger settler is the feed to the purification slime treatment plant.

The scavenger spigot product is pumped to two 10 by 17 ft. leaching Pachuca tanks until they are about one-third full, then cell acid (10% sulphuric acid) is run in slowly while the tanks are agitated until copper begins to go into solution. At this point, the zinc and cadmium are in solution while the copper is still in the solid state. These leaches are now pumped to the copper settler, where the copper is collected in a rich slime, 30% copper in the spigot product, and is filtered on a 12 by 12 ft. Oliver filter and sent to the copper smelter. The overflow of the copper settler contains the cadmium and zinc and is run to two 10 by 17 ft. Pachuca purifying tanks, to which fine zinc dust is added in sufficient quantity to reduce the cadmium content of the solution to that of the neutral Dorr overflow. After the cadmium is precipitated, these tanks are discharged to a 10 by 30 ft. cadmium settler, the overflow of which goes back with the scavenger settler overflow for purification. The spigot product of the cadmium settler contains 12% cadmium and is to be treated for the recovery of metallic cadmium. Approximately 500 lb. of cadmium per day is contained in this product. The process for the recovery of cadmium has been worked out and the plant will, most probably, be installed when the demand for cadmium justifies it.

(To be continued).

HEAT TREATMENT IN SHARPENING DRILL STEELS.

In the *Mine and Quarry* for April, J. A. Noyes and J. M. [illegible] discuss the scientific principles underlying the heating of drill steels prior to sharpening. It is becoming generally recognized that the rule of thumb methods usually followed in the mine-drill sharpening shop must be supplanted by a systematic yet practical application of known facts about the physical properties of high-carbon steel. This article makes a few practical suggestions regarding the proper heating, forging, and tempering of high-carbon drill-steel.

In the discussion of the proper forging and tempering temperatures, it is first necessary to understand what is meant by the critical point of the steel. The critical range can be ascertained by watching the slow heating of a piece of steel in the furnace. The steel brightens in colour with the rising heat of the furnace until a point is reached where the steel apparently becomes a trifle darker and cooler than the furnace. If the heating continues, the steel again increases in brightness, once more assuming the same brilliancy and temperature as the furnace. The darkening is due to the absorption of heat and the temperature at which this absorption takes place is known as the decalescent or critical point. At this point the ferrite and pearlite are converted into austenite. If the furnace is now allowed to cool slowly, a point will be reached where the steel remains visibly brighter than the furnace, but in a few seconds it again assumes the colour of the furnace and darkens with it. This brightening of colour is due to the throwing-off of heat and is the recalescent point, where the austenite changes back to ferrite and pearlite. The decalescent point on the rising heat is at a higher temperature than the recalescent point of cooling. For practical purposes, the critical point is the decalescent point, and the critical range includes the temperatures just above the critical point. The critical point of steel is different for steels of different carbon contents. For drill steel averaging 0·60% to 0·90% carbon, the critical range is from 1,420° to 1,350°F. By coincidence this steel becomes non-magnetic at a temperature which for all practical purposes is the same as the critical temperature of the steel. This fact therefore affords a simple, easy method of determining the critical point of any drill steel regardless of its carbon content. By bringing the heated drill bit up close to an ordinary horse-shoe magnet, it can be determined whether or not the temperature of the bit is above the critical range of the steel by merely noting whether or not the magnet is attracted by the hot steel. If the magnet is attracted, the temperature is below the critical point. If it is not attracted by the steel, the critical temperature has been passed.

The structure and physical properties of the drill bit depend on the temperatures used for heating the steel preceding both forging and quenching, as well as on the care exercised in the mechanical working or forging of the bit. The finest grain size obtainable exists just as the steel passes through the critical range on the rising heat. Further heating above the critical temperature coarsens the grain, and this coarse structure remains in the steel if it is allowed to cool undisturbed. If, instead of allowing the steel to cool undisturbed, it is vigorously hammered, the coarse crystalline structure can be broken up and the grain refined. If, however, the hammering is stopped above the critical range, the coarse crystallization sets in again, and the higher the temperature above the critical range at which the forging stops, the coarser the structure will be. The finishing temperature for the forging operation of the drill-steel bit should therefore be at or slightly above the critical temperature, and the forging should be by rapid, vigorous hammering and not by "bulldozing" or "squeezing." It is a well-known fact that hammered forgings command a much higher price than drop forgings, where the metal is literally pressed into shape at high temperatures. The forging operation should not continue below the critical range, because cold working below this heat causes distortions and internal strains, which result in brittleness and in steel breakage.

Heating in a coal forge is unsatisfactory, as the abundance of oxygen required for the combustion of the coal gives a heavy oxidizing flame, causing excessive scaling of the steel. Coke is only slightly better as a fuel. With both coal and coke furnaces, it is almost impossible to get a close regulation of temperature. In heating steel, it expands, except in passing through the critical range, at which point it contracts. Therefore, if a piece of cold steel is thrust into a raging hot fire, the outer surfaces are passing through the critical range and are contracting, whereas the centre of the bit is still expanding, having not yet reached the critical temperature. This causes cracking and checking of the steel. In the same way, even if the steel is not thrust directly into a raging open fire, but is only inserted directly into the combustion chamber of a furnace, where the extreme high temperature flames are allowed to impinge directly against the drill bits, this same condition will result, and either cracking or checking of the bits takes place. It is a well-known fact that if the higher carbon steels are allowed to remain in a hot furnace for any great length of time the carbon is precipitated in the form of graphite, and when this occurs, the steel is greatly reduced in efficiency, even if not entirely ruined. It is common practice in drill-sharpening shops for the smith to allow the drill steel to remain in the furnace while making adjustments on the drill-sharpening machine, changing dollies, or making minor repairs, and this is sure to prove costly in the end, as the outer surface of the steel becomes decarbonized and will not respond to the same heat treatment that is effective before the soaking takes place. This soaking also increases the coarseness of tructure, as coarseness of structure not only increases with high temperatures, but also with the length of time for which the steel is held at the high temperature. The maximum temperature for forging drill steel should not exceed 1,650° to 1,750°F. Temperatures higher than this coarsen the structure to such an extent that even the thorough hammering during the forging operation cannot again refine the grain. The result of too high a forging heat is checked, cracked, and brittle bits, irrespective of what the subsequent tempering treatment may be.

In tempering all drill bits, quenching should take place at the critical temperature or at about 50°F. above this point and on a rising heat. When quenching takes place at this temperature, maximum density and toughness, with maximum hardness, are secured. The heating preceding the quenching should be slow, uniform, and thorough, and at the lowest possible temperature that will secure the desired results. The furnace temperature should be slightly above the critical point of the steel to compensate for some loss of heat while transferring the steel from the furnace to the quenching bath. Heating for quenching cannot be done satisfactorily in a coal or coke furnace, where close regulation of temperature is impossible. Overheating is the cause of 90% of the bad results from

drill steel. Unfortunately many practical smiths still believe in the efficiency of high temperatures for greater hardening effect. While to a very limited extent it may hold true that the higher the temperature the harder the steel, the questionable gain in hardness is more than offset by increased coarseness in the grain of the steel, and by internal strains, both resulting in faster wear on the bits, and more breakage. Heating for hardening requires great care. The rapid quenching of hot steel is the most severe test that steel can be put to. If the heating is not uniform, it naturally follows that the bit after quenching will be subjected to severe internal strains. Hardening cracks are therefore more often a result of improper heating than of any defect in the steel.

To emphasize the importance of quenching steel at the lowest possible temperature and still be above the critical point, the authors cite a test that was made on two gears that were machined from the same bar of steel, and given identically the same heat treatment, with the single exception that gear B was quenched at a temperature 50° higher than gear A. Both gears showed the same degree of hardness. While it required 48 blows of a 10 lb. hammer dropping 30 in. to break a tooth out of gear B, it required 200 blows of the same hammer falling the same distance before a tooth could be broken out of gear A. This difference of only 50° lower quenching temperature resulted in 400% increase in toughness. This example clearly illustrates that in order to get the maximum wear-resisting qualities in a drill bit, the quenching should be at the temperature at which the magnetism leaves the steel, and thus theory and practice both support the old rule that the lowest temperature that gives the desired results is the best temperature.

One of the conditions that works a hardship on the drill smith in the average drill shop is having to handle steel which contains varying percentages of carbon. Steel containing 0·90% carbon does not require as high a temperature for hardening as a piece which contains 0·50% carbon. If both steels were quenched at a temperature suitable for the higher carbon steel, the other steel having a lower percentage of carbon would be too soft. If the quenching temperature is raised high enough to secure the proper hardness of the 0·50% carbon steel, and if the steel with the higher carbon content is quenched at this higher temperature, breakage and chipping of the bit is practically certain. This may cause the blacksmith a great deal of trouble, as in one section of the mine there may be a complaint about the steel being too soft, while other sections of the same mine will report the steel as being too hard.

The authors describe an inexpensive electrical indicator for determining when the steel has reached the decalescent point. This is an ordinary horse-shoe magnet hung from a fibre or other non-conducting support. At the upper end of the support is a copper contact for closing an ordinary light circuit. This indicator is more serviceable in the shop than an ordinary horse-shoe magnet hung from a cord. When the heated bit is pressed against the copper plate the light will flash if the steel is at too low a temperature for quenching. The correct heat for quenching is when the magnetism leaves the steel. This indicator gives one of the two necessary facts about the temperature of the steel for quenching. It is the fact that the steel is hot enough, having passed the critical temperature. The second fact that must be known is that the temperature is not too high. This can be assured by using an oil or gas furnace, the maximum temperature of which is indicated by a pyrometer. If the maximum temperature of the furnace is maintained at a predetermined point, there will be no danger of overheating the steel, irrespective of the time the steel remains in the furnace, within reasonable limits. In the past it has been the general practice to insert the drill bits into a raging hot furnace and depend on the watchfulness and skill of the operator to judge when the proper temperature has been reached. Naturally the results have varied with different men, different light conditions, and with the conglomeration of steel of several makes, and various chemical compositions.

When the proper temperature is secured, quenching should be rapid. The object of quenching is to retain the characteristics which the proper heating has developed. The most satisfactory quenching medium for drill steel is circulating cold water. For uniform results the temperature of the water should be kept fairly constant. The effectiveness of water as a quenching medium falls off rapidly above 100°F. Brine solution is a faster quenching medium than water, but its effectiveness decreases with increased temperature, particularly where large quantities of steel are handled. Oil is used as a quenching medium where a high degree of hardness is not necessary.

The design of a safe, efficient drill-steel furnace is an engineering problem, and it must be treated as such. A drill-steel furnace must operate at different temperatures, as the degree of heat required for hardening is different from that required for forging. The temperature control must be accurate at different heats. Consideration must be given to the time required for heating. The part of the steel to be heated must be considered; for example, a short heat at the end of the steel when tempering bits or a forging heat at a point five inches from the end when forming lugged shanks. Fuel consumption cannot be treated by itself. It involves proper and complete combustion of the fuel as well as the results desired. The heat developed must be used and not wasted. The authors proceed to give details of the Sullivan drill-steel furnace. This is a low-pressure oil or gas furnace of the underfed type. The combustion chamber is located below the adjustable hearths. The slot width between the hearths can be varied from ½ in. to nearly the full width of the combustion chamber. This permits heating the bar of steel with any length of heat and at any point along the bar. This is a particularly valuable and serviceable feature in forming collared or lugged shanks. At the hot end of the furnace is a thermo-couple which registers the temperature in connection with a pyrometer indicating apparatus. The temperature at the point where the drill bits are withdrawn from the furnace can, therefore, be kept at any predetermined point by regulating the fuel supply, thus maintaining the desired heat as indicated by the pyrometer. For example, in heating the steel for quenching, the pointer on the instrument may be set at 1,450°F. When the temperature in the furnace at the point of withdrawal of the steel, which is where the hot end of the thermo-couple is located, is at 1,450°F., a white electric light will burn. If the temperature increases 25° the white light goes out and a red light comes on. If the temperature drops 25° below the figure at which the pointer is set, a green light burns. In heating for forging the pointer on the instrument can be set at a higher temperature, for example, at 1,650°F., and the three coloured electric lights again operate to indicate correct, high and low temperatures. In this furnace the combustion of the fuel takes place below the hearths in the combustion chamber. When the furnace is up to heat, the combustion chamber, hearth pieces, and the adjustable brick stop become incandescent and the drill bits are heated by an indirect or reflected heat. Oxidizing or scaling of the surface

of the bits is thus prevented. The steel cannot be inserted directly in the combustion chamber. The steel cannot be overheated, as the maximum temperature at the hot end of the furnace is a safe heat and is checked with the pyrometer. The length of heat on the steel can be kept short by narrowing the width of the slot between the hearths. In the normal operation of this furnace, it is kept well filled with steel, practically closing the slot opening from the combustion chamber, resulting in increased fuel economy. The cold steel is put in at the burner end, which is the cold end of the furnace. As the heated steels are withdrawn at the other end, the others are rolled along toward the hot end, so the heating is progressive, slow, uniform, and thorough. Overheating of the steel is impossible. Although the construction of this furnace is comparatively simple, the exact proportioning of the combustion chamber, the location and height of the hearth and hood pieces, the type and position of the burner, the details of the adjustable drill rest, have all been arrived at by a development process under actual working conditions.

Globe & Phœnix Metallurgy.—The January *Journal* of the Chemical, Metallurgical, and Mining Society of South Africa contains a paper by V. E. Robinson on the present method of treatment of the ore at the Globe & Phœnix gold mines, Southern Rhodesia. It will be remembered that an article by H. T. Brett was published in the MAGAZINE for July, 1911, but the methods there described have been largely superseded.

An analysis of the ore given by Mr. Brett is as follows: SiO_2 and insoluble, 76·32 %; Sb, 0·73 %; Fe, 2·58 %; S, 0·96 %; CaO, 1·21 %; MgO, 0·44 %; As, trace; Cu, trace. The amount of antimony, however, varies considerably. Screen samples, taken over a period of three weeks, have contained as much as 2·39 % Sb and 0·26 % As, while the massive stibnite removed by sorting contains up to 80 % Sb_2S_3. Much of the gold present in the ore is free, and easily caught on amalgamated plates; some of it is coated, but can be amalgamated in grinding pans; and some escapes the pans but can be retained on canvas strakes. Owing to the stibnite present, and also possibly to ferrous iron, the tailing cannot be treated directly by cyanide, but if it be allowed to partly oxidize by weathering, it becomes amenable to cyaniding. After breaking and sorting, the ore is wet-crushed by stamps and passes over amalgamated plates to grinding pans. It then flows over canvas strakes to a classifier, which separates sand from slime. The sand is discharged to the dump, and the slime to dams. Both products are allowed to oxidize by weathering, after which the sand is ground in tube-mills in cyanide solution, and treated by counter-current continuous decantation, while the slime is treated by the ordinary decantation method.

The author proceeds to give details of the processes. The ore is trammed from the shaft bin, and dumped on steel grizzlies, with 1½ in. openings and set at an angle of 50°. The oversize is fed to two 15 in. by 9 in. Blake-Marsden breakers, whence it is conveyed by belt to a screening and washing trommel. Fines go direct to the mill bin; the remainder, before entering the bin, is fed on to a sorting belt, where waste rock and stibnite are removed, and discharged to their respective dumps. About half a ton of massive stibnite is sorted out per day. The greater portion of the stibnite remaining in the ore is present in the fines.

The mill is equipped with 40 stamps of 1,250 lb. weight, using 200 mesh screens (200 holes per sq. in.), with a drop of 8½ in., and making 108 drops to the minute, the stamp duty being 5·75 tons per day. From the mortar-boxes the pulp flows over eight amalgamated copper plates, 12 ft. in length, of which the lower 4 ft. is covered with blanket. From the plates the pulp passes to twelve 5 ft. grinding pans, to which mercury is added. These pans run at 48 r.p.m. Their shoes and dies are made on the mine, a set lasting on an average 60 days. The pan discharge passes over canvas strakes, then through three mercury traps to a large launder designed as an auxiliary mercury trap, thence to the tailing pump. This auxiliary mercury trap consists of a wide launder having several layers of heavy screening (½ in. aperture) fastened to the bottom. The strakes cover a rectangle 19 ft. long by 53 ft. broad, and are stepped in the centre. The strake product is reconcentrated over a small strake, the discharge of which passes back into the grinding pans. This concentrate is very fine, so that during barrel treatment it is mixed with coarse river sand, and a few tube-mill pebbles. To promote efficient amalgamation a little sodium cyanide is added, which acts as a desulphurizing agent, keeping the mercury clean. It dissolves no gold. From 65 % to 70 % of the gold content of the ore is recovered by amalgamation, of which 60 % comes from the plates, 13 % from the blankets at bottom of plates, 19 % from the pans, and 8 % from the canvas strakes. The width of the strakes is of more importance than their length, and if, through insufficient space, their width must be curtailed, it will be found advantageous to install step tables, with a drop every 6 ft. The fall should be 1½ in. per foot, and a convenient size for each strake is 30 in. wide. The blankets should not be more than 36 in. long, this length being handled easily. Canvas is superior to blanket in saving fine gold. When first discharged both sand and slime have a dull bluish-grey appearance, but as oxidation proceeds this changes to a yellowish colour.

The capacity of the sand plant is 300 to 320 tons per 24 hours, and an extraction of 75 % to 80 % of the gold content is obtained. Grading analysis of dump sand before regrinding shows:

Mesh	%
+ 30	5
– 30 + 60	24
– 60 + 90	25
– 90 + 150	18
– 150	28

Different sections of the sand dump, however, vary a great deal, and the sand now being discharged from the mill contains only 25 % of + 90 mesh after regrinding, the residue grading showing about 15 to 20 % of + 150 mesh. The tube-mill pebbles used are obtained from adjacent river beds. Waste rock has been used, but is inferior to these pebbles. The cyanide strength is kept at about 0·03 % KCN in the tube-mill circuit and agitators; 1·1 lb. cyanide and 0·2 lb. lead nitrate are consumed per ton. The sand is conveyed from the dump to the treatment plant by mechanical haulage.

The dams for accumulating the current slime occupy an area of about 5 acres, divided into three separate portions, each being 6 ft. deep, so that, while one is being filled, another is full awaiting treatment, and the third is under treatment. When a dam is full, it is allowed to dry sufficiently to hold the weight of the oxen and plough. The whole surface is then ploughed over several times, at intervals of five to six weeks. When treatment is commenced on a dam, half the ploughed area is removed to a depth of 14 in., and taken to the treatment plant. The rails are then shifted to the other half of the ploughed area, which in its turn is treated, and while treatment of this second half is proceeding,

the first half is reploughed several times. This procedure is continued until the dam is exhausted. The ploughed and oxidized slime is trammed by oxen to a vortex mixer. The cyanide treatment is carried out in circulation and decantation tanks, circulation and transfer being effected by pumps. The cyanide consumption is about 1·6 lb. per ton treated. An extraction of close on 80% of the gold content is obtained.

Precipitation on the whole is good, although the zinc is apt to become plated with gold. The solution from the sand treatment plant gives far less trouble than that from the slime plant, and the products of the two plants are kept separate throughout clean-up and smelting. In the slime boxes, a varying amount of copper is precipitated in the lower compartments. The smelting equipment consists of a paraffin oil-fired tilting furnace, taking a No. 400 crucible; three coke furnaces; one two-tray calcining furnace, and a retort. Slags and other by-products are treated in a Taverner furnace. The retort is of the usual design. A small amount of antimony present in the amalgam causes objectionable fuming when taking sponge from retort, and also makes the gold very brittle. After the precipitate from the sand plant is smelted, it is refined by re-melting with an oxidizing flux in clay-lined pots, skimmed, and a blast of dry compressed air allowed to play on the surface of the molten metal for from one to two hours. The iron pipe, ½ in. diameter, delivering the air, is kept about 4 in. from the surface of the metal, and just sufficient air is turned on to give a faint ripple over the surface; antimony, and other easily volatilized metals come off in dense fumes until completion of the operation. The bars are cast under a borax cover, and assay over 800 fine. The slime bullion requires different treatment owing to the large amount of copper often present. It is granulated, mixed with sulphur, and heated slowly in a graphite pot. Most of the copper and other base metals, as well as part of the silver, enter the matte, but antimony is not entirely removed. After the charge has been fused, poured, and the matte removed, the bullion obtained is re-melted in a clay-lined pot with an oxidizing flux, then skimmed and toughened by compressed air. The matte is crushed fine, mixed with an equal weight of borax, and quarter its weight of crushed cyanide, and heated in a graphite pot until all action ceases. The matte is now decomposed, and practically all the gold and silver are recovered as fairly good bullion, which is further refined by oxidation, and is then included with the bullion obtained from the sulphur treatment.

A considerable amount of experimental work has clearly demonstrated the desirability of weathering before treatment. Tests quoted by the author show a recovery of 84·2% and a consumption of 1·5 lb. cyanide per ton with weathered sand, and 60·5% and 2·8 lb. with current sand. The period required for oxidation varies according to conditions. The slime might remain in the dams for years, without any visible change taking place, but as soon as it is ploughed, and thus exposed to the air, the change to a yellowish colour commences. Under the best conditions, slime will oxidize sufficiently for treatment in about 20 days. Under working conditions each half of a dam will receive two ploughings in approximately six weeks. As a general rule, the sand will be on the dump over six months before it is treated, though under favourable conditions, such as small bulk, it would be ready for treatment in a much shorter period. Occasionally, when the antimony contents are low, a fairly good extraction may be obtained without preliminary oxidation by weathering. The use of a certain amount of lime in treating the oxidized material is desirable, as it decreases the cyanide consumption, but too much is fatal to a good extraction.

Calcium.—At the meeting of the Institute of Metals held in March, P. H. Brace presented a paper on calcium, its history, properties, and manufacture. We give here a brief abstract.

Sir Humphry Davy appears to have been the first to isolate traces of calcium by the electrolysis of moist lime; though while Davy's work was in progress he received a letter from Berzelius and Pontin which described the results of their experiments on the electrolysis of the alkaline earths with mercury cathodes. Davy repeated these experiments and secured amalgams of calcium and the other alkaline earths, confirming the conclusions of Berzelius and Pontin. In 1854 Bunsen prepared small quantities of calcium by electrolysing an aqueous solution of the chloride with a mercury cathode and subsequently distilling off the mercury. Matthiesen, in 1856, prepared small quantities of impure metallic calcium by the electrolysis of a fused mixture of strontium chloride and calcium chloride. Comparatively little interest was shown in the subject until Moissan, in 1898, published his results which showed that nearly pure calcium could be prepared by the reduction of calcium iodide by means of sodium. In the same paper Moissan mentions the electrolytic preparation of calcium from the fused iodide. In the same year he published an extensive list of the properties of the calcium prepared by the sodium reduction method. In 1898 Bela von Lengyel gave an account of the properties of calcium prepared in a cell with a porous diaphragm. Borchers and Stockem described a calcium cell in which the metal was deposited in the form of a sponge on a water-cooled cathode projecting upward from the bottom of the cell submerged in the electrolyte of fused calcium chloride. A similar cell was used in 1903 by Goodwin, but he operated at a higher current density and temperature, and so caused the calcium to collect in the molten state and rise to the top of the bath, whence it was removed by means of a ladle. Shortly after this, in 1904, Rathenau made the next noteworthy advance when he used a cathode which just touched the surface of the molten electrolyte, and operated it at such a current density that the surface of the calcium in contact with the electrolyte was kept molten. The cathode was gradually elevated as the metal accumulated, and an irregular rod was thus built up. This method was commercially successful. Goodwin, in 1904, published the results of extensive experiments with an apparatus of the Rathenau type, and gave an account of the physical properties of the calcium he had prepared. In 1905 Wohler reported on his experiments in which an electrolyte containing 100 parts of $CaCl_2$ and 17 parts of CaF_2 was used. He believed that the low melting point of the above mixture was an advantage, but the experience of others has since indicated that there are disadvantages which more than outweigh the convenience of the low melting point. Arndt described the preparation of calcium-aluminium alloys by the electrolysis of calcium chloride with an aluminium cathode. Alloys containing between approximately 20 and 80% of calcium are described, but no particularly useful properties are mentioned. In 1909 Frary and Badger published a comprehensive bibliography of calcium metallurgy, followed by a description of the results of their work with the Rathenau form of cell, and in the following year, Frary, Bicknell, and Tronson discussed the efficiency of the apparatus just mentioned, and concluded that practically 100% current efficiency could be obtained by proper manipulation. They were of the opinion that pure calcium chloride made a more satisfactory electrolyte than the

calcium fluoride-calcium chloride mixture of Wohler. At the same time Johnson published an account of a series of experiments with the submerged cathode cell of Borchers and Stockem, and the Rathenau cell, and described the development and operation of a novel apparatus in which the metal was deposited on a perpendicular, vertically-moving iron ribbon cathode which closed the narrow end of a V-shaped enclosure containing the electrolyte. The wall of the enclosure opposite the ribbon was of graphite, and formed the anode. The cathode current density was kept considerably lower than in the case of the Rathenau cell, and it appears that the calcium was deposited in the solid state, producing a thick plate on the iron ribbon in much the same way as metals are ordinarily deposited from aqueous solutions. In 1909 Cowper-Coles patented a process for the electrolytic preparation of calcium and similar metals, the principal feature of which was the use of a cathode in the form of a disc whose edge just touched the surface of the electrolyte, and which was rotated as the deposit collected. In 1911 a refining process was described in a French patent, which had in view the elimination of the included chloride and other mechanically held impurities from calcium produced by the Rathenau and similar methods. In this process the calcium was melted under calcium chloride and collected under an inverted conical iron bell submerged in the molten chloride. The idea was that the calcium would separate completely from the chloride and other impurities by virtue of the differences in their densities. Moldenhauer and Anderson, in 1913, described experiments with mixed fused electrolytes in which calcium alloys with zinc and some other metals were produced. In 1920 the writer (Mr. Brace) published a short account of some experiments on the electrolytic production of calcium, and described a new type of cell.

Of the properties of calcium, the most important are its low specific gravity, 1·548, and the fact that it decomposes water. The list of calcium alloys that have been prepared and investigated is large. The outstanding general properties seem to be brittleness and the tendency to the formation of intermetallic compounds. Very few of the calcium alloys appear to have any usefulness as structural materials. Aluminium-rich alloys may find application because of their slight advantage in weight over pure aluminium. Lead alloys containing calcium and other alkaline earth metals are finding application as bearing metals for service such as the usual white metals are put to. Barr has published the results of an extensive investigation of the properties of a number of calcium alloys by the method of thermal analysis. Calcium was alloyed with thallium, lead, copper, and silver, and in every case definite evidence of the occurrence of intermetallic compounds was secured. Moldenhauer and Anderson investigated the direct production of calcium alloys from fused mixed electrolytes. Zinc, aluminium, and potassium alloys were prepared. Cooper has patented alloys of calcium with aluminium, in which the calcium content may be as high as 8%. The claims make a feature of lightness, ductility, and ease of machining. Kroll has patented the use of calcium and its light alloys as a filling for hollow steel structural members. He has claimed that, as compared with nickel-chromium steel, structures made according to his patent have the same strength with but 41·56% of their weight. Hirsch and Aston experimented with the production of iron alloys, and state that up to 6% of calcium may be alloyed with iron by reducing Fe_2O_3 in gas-tight iron cylinders. They state that calcium destroys the welding property of iron. Watts and Breckenridge used the brittle alloys of calcium with aluminium, silicon, and manganese as reducing agents in the course of experiments on the preparation of some of the more difficultly reducible metals. The brittleness of the alloys was found a great convenience, as it enabled them to be pulverized and brought into an intimate mixture with the substances to be reduced. Stockem stated that calcium dissolved in cast iron with the evolution of considerable heat, and that if considerable amounts of calcium were added a scum of calcium carbide collected on the surface of the molten metal. He also stated that calcium alloys with copper in all proportions, and that some of these alloys are useful as deoxidizers and scavengers in non-ferrous alloys. Watts found that calcium acted as a powerful desulphurizer of molten low-carbon iron, but that the effect on the phosphorus content was relatively small. Hackspill prepared lead alloys by the reduction of lead chloride with an excess of calcium. The alloys were harder and less brittle than lead and tarnished in the air. They were slowly attacked by cold water, and more rapidly by hot water. A crystalline alloy, Pb_3Ca_2, was isolated by distillation *in vacuo*. A summary of the more important uses of metallic calcium is as follows: (1) As a reducing agent in the preparation of metals and alloys from their oxygen and halogen compounds. (2) As a reagent in the purification of the inert gases. (3) As a scavenger in non-ferrous metals and alloys. (4) As a scavenger, decarburizer, and desulphurizer of ferrous alloys. (5) As a dehydrating agent, as in the treatment of oils and alcohols, for example. (6) As a means of fixing atmospheric nitrogen. (7) As a source of pure calcium carbide by direct reaction with pure carbon. (8) As a stiffening filling for hollow metal structural members. (9) As a constituent of a light aluminium alloy having useful properties. (10) As a hardening component in certain lead-base anti-friction alloys.

There are three general methods for the preparation of calcium, as follow: (1) By the reduction of calcium compounds by metals of the alkali group. (2) By the electrolysis of concentrated aqueous solutions with a mercury cathode. (3) The electrolysis of fused halogen compounds of calcium. Of these three methods the last is by far the simplest and most direct.

Fire-Damp in Gold Mines.—During the last few years there have been a number of fire-damp explosions in gold mines in the Far East Rand, notably at Brakpan, Government Areas, and Daggafontein. The general supposition is that the fire-damp has its origin in the Coal Measures several thousand feet above the reef. A paper on this subject was read by T. N. Dewar at the February meeting of the Chemical, Metallurgical, & Mining Society of South Africa. We quote from this paper two instances of accidents that have occurred at Brakpan.

In the Brakpan, the first accident happened in No. 2 shaft section, on March 19, 1913. The No. 8 West winze dipped at an angle of 15° to 20° for 270 ft., and then rose gently for 130 ft. Two small dykes were passed through, one on the slope and the other up the rise. A fissure was encountered at the face from which a large quantity of water issued, and the winze became partly flooded. A pump was installed to handle the water. As the water-level fell suddenly a pumpman went down to ascertain the cause and found the water had fallen about 4 in. from the hanging in the hollow. On holding his lamp up to make the inspection, an explosion occurred and he sustained fatal injuries. Later on it was ascertained by tests that the gas issuing from the fissure was fire-damp. The gas had accumulated behind the water in the hollow and was released by the lowering of the water-level to the pump. The depth from the surface to the face of the winze was about

3,470 ft. On August 26, 1915, the fire-damp was met with in a different part of the same mine. In going through with a cross-cut in the 17 East-level an upthrow fault with a 70 ft. throw was encountered. It was intended to put up a boxhole from the 17th to the 16th levels, so a rise 9 ft. by 7 ft. was started at a slope of 30° and struck the fault at about 30 ft. up. Continuing through the foot-wall shales at an angle of 60° the rise reached a length of about 120 ft. A slight trace of fire-damp had been met with on July 13, 1915, and a native was burnt, so ventilation had been provided for by 6 in. galvanized iron piping and a fan. Despite this, more gas came off and an accident happened on August 26, whereby the trammer and a native were seriously burnt, the latter succumbing to his injuries. Apart from the fault there was no fissuring in the shales and the place was dry. The depth from the surface to the scene of the accident was a little over 4,000 ft.

The author proceeds to give an explanation of the presence of the fire-damp. Looking at the geology of the country in the neighbourhood of the mines mentioned, it is found that basins of coal-bearing Karroo rocks overlie the dolomites, which in turn overlie the Witwatersrand series. In several of the shafts the dreaded "Green Dyke" is found, a dolerite sheet which weathers and gives great trouble with pressure on the timbers. It occurs in the No. 1 and No. 3 shafts, Springs Mines, No. 1 and No. 2 shafts, Daggafontein, and attains its greatest thickness of 95 ft. in the South shaft of the New State Areas. A syenite sheet split up into several sections appears in most of the shafts in the south and east of the Far East Rand. At No. 2 shaft, Springs Mines, it totals 220 ft. in two sections. Interbedded in places with the syenite sheet is the dolomite, which attains its greatest development in four sections at Daggafontein No. 1 shaft, where it has a thickness of 436 ft. The Coal Measures are in the form of basins of very varying thickness. Taking an average of eleven shafts situated in Brakpan, Government Gold Mining Areas, New State Areas, Springs, and Daggafontein, the average thickness to the base of the Dwyka conglomerate is 148 ft. In this area the coal seams average 19 ft. in thickness, and attain their greatest development in a line running south and east of the gold mines. The seams have been or are being worked at Apex, Brakpan, Rand Colliery, Schapenrust, and De Rietfontein, a belt of 13,000 yards long. Brakpan colliery was worked over the present Brakpan mines, but the other collieries have no gold mining going on at present underneath them. At De Rietfontein colliery, when it was working, bubbles of fire-damp were sometimes found issuing from the foot-wall. Though the Coal Measures are well developed in the three shafts of the Springs mines, no fire-damp has been found in that mine, which will probably in time work under the abandoned De Rietfontein colliery. Taking the three mines particularly concerned in this paper, the Brakpan No. 2 shaft has a 14 ft. seam of coal in the 144 ft. of Karroo rocks. The Government Gold Mining Areas, the south-east shaft, has no coal in 90 ft. of sandstones. The Daggafontein No. 1 shaft showed no coal in 72 ft. of sandstones, but the No. 2 shaft, 2,000 yards to the west, had 50 ft. of inferior coal in 175 ft. of Measures. The surface elevations show that the coal has been denuded at No. 1 shaft near the Blesbok Spruit. At the Largo colliery, where a little fire-damp was found recently, the development of the Coal Measures is typical. There are three seams of coal, totalling 34 ft. in a thickness of 193 ft. Gas has only been met with in the lower seam, which has a thickness of about 10 ft. It is overlain by a dense close-grained shale of about 8 ft. All the strata above this dense shale are porous, and no gas is found in the two upper seams. The lower seam referred to overlies 3 ft. of Dwyka shales which rest on the Dwyka conglomerate.

It is noticeable from the occurrences described that the fire-damp in the mines of the Far East Rand is found principally in the presence of upthrow faults which bring the foot-wall shales into position for driving through. In the majority of cases, faulting and water seem necessary for the presence of gas. In some cases sulphuretted hydrogen accompanies the fire-damp, but not always. It is assumed by many people that the gas travels with the water down fault planes from the Coal Measures. The great problem is to account for the vertical movement of the gas of nearly 4,000 ft. In the Apex old colliery a little fault came through on the east side of the shaft. This was about 1896, and a good supply of water came off the fault. A sump was made and an electric pump installed to raise the water to the surface for boiler and domestic use. The workings of the colliery steadily progressed away from that area, and the supply remained undiminished. Some water overflowed into the abandoned workings near the shaft and remained there for years. About 1906 the Brakpan mines began to develop from the No. 2 shaft, 1,500 yards distant. As the drives came forward toward the Apex, the spring suddenly disappeared, and the water in the workings followed suit. It would, therefore, appear that in places there is a definite connection through faulting from the Coal Measures to the gold zone. The dolomites form a very convenient water channel all over the area. They are jointed and large quantities of water lie in the crevices. For instance, during cementation work at Brakpan No. 3 shaft, small plates of cement were found in sinking through the dolomite in the south shaft of the New State Areas 3,300 yards away.

The difficulty is just why fire-damp should not take the line of least resistance and escape up the faults to the surface, instead of travelling down them. The fact remains that fire-damp is generally found in mines where the Coal Measures are developed above or where a connection with them is available through the dolomites for gas to travel. On the other hand it is to be noticed that the gas is usually found actually in or about the foot-wall shales which are very jointed. Carbon is also found occasionally on the contact of the reef and the shale where, especially if associated with pyrites, a great enrichment of values takes place. Perhaps under heat and pressure some reaction may take place between the pyrites, water, and carbon in or under the shales to produce something in the shape of fire-damp.

Redmayne, in the "Ventilation of Mines," states that a blower of fire-damp has occurred from time to time in the Van lead mine, near Llanidloes, in Montgomeryshire, the vein of which traverses rocks of the Lower Silurian age. It is difficult to account for the presence of fire-damp at this mine as there are no Carboniferous rocks in the neighbourhood, and decaying timber could not account for the existence of a blower of gas. Possibly it owes its origin to the decay of plant or animal life of the Silurian period, and has been pent up through the succeeding ages, or it may be due to the chemical action of acidulated waters or mineral substances. It is a peculiar feature of the emissions at this mine that they are accompanied by sulphuretted hydrogen.

The difficulty in connection with occurrences of fire-damp in metalliferous mines is the fact that very few of the men working there have any knowledge of fire-damp. It constitutes a danger when it comes in contact with people who have not even heard of it. Its presence is often first announced by fatal burning accidents. In these deep mines the temperature of the workings is

generally fairly high, about 75° to 85°. European and natives alike work with a minimum of clothing, and when an accident happens, the burning is severe owing to the amount of skin exposed.

Trevorite. In our issue of August, 1920, brief mention was made of a new discovery of nickel in South Africa, the mineral being apparently a new one. At the February meeting of the Chemical, Metallurgical, & Mining Society of South Africa, Andrew F. Crosse exhibited the mineral, which assays as follows:

	%
Nickel Oxide	[illegible]
Iron Oxide	[illegible]
[illegible]	[illegible]
Calcium Oxide	0·20
Silica	[illegible]
Loss on ignition, chiefly water	15

The metallic nickel content is 29·6%, and metallic iron content 35·7%; platinum was present in the sample to the extent of 0·2 dwt. per ton. Mr. Crosse also exhibited an alloy of iron, containing 52% nickel, made by smelting this ore. There is no arsenic or sulphur in the mineral, and the crude ore can be concentrated on tables or magnetically. Mr. Crosse proposes to name the mineral "trevorite," after T. G. Trevor, Mining Inspector for the Pretoria and Barberton districts. Mr. Trevor proceeded to give some account of the occurrence. The deposit is found on the Lily line in the Jamestown Series, just opposite Sheba Bridge, Barberton district. Particulars were given in the short article in August last, as already mentioned.

The Mackenzie Oilfield.—At the meeting of the Institution of Petroleum Technologists held on April 27, Dr. T. O. Bosworth read a paper on the recently discovered oilfield near Fort Norman on the Mackenzie River, in the North-West Territories of Canada. Dr. Bosworth was engaged a few years ago in geological investigations in connection with oil in this part of the world. The new oilfield is the most northerly of the prospective fields then examined, and the flowing well recently brought in is No. 1 test-well located during his expedition seven years ago.

Within the region discussed by Dr. Bosworth in the present paper petroleum appears to have been first recorded about a century ago by Sir John Franklin, who saw, near Bear Mountain, "sulphurous springs and streams of mineral pitch." Also, for the past fifty years or more, a "tar spring," far inland from the river, has been known to the Hudson Bay Company's men at Fort Good Hope, who have utilized this seepage oil for tarring their canoes. In 1887 an exploration of the Mackenzie Basin was made by R. G. McConnel, who reported in the Annual Report of the Geological Survey of Canada, 1888–9, the occurrences of bituminous or petroliferous rocks throughout the valley. From that date onward no further geological study of the region was made until the investigation by Dr. Bosworth, in 1914. It was not until 1919 that a drilling outfit was conveyed into the North-West Territory, the oil claims having been acquired by the Imperial Oil Company, who were conducting an exhaustive search for oil throughout Canada. The location of this first test well was chosen in 1914, as a site where a hole of moderate depth could not fail to penetrate the several petroliferous formations which had been found. The well is on the river bank about half-way down the Long Reach, near the mouth of Camp Creek, where there are copious seepages of oil. Geologically speaking, the location is upon the outcrop of the lower measures of the Camp Creek Series, low down on the south-west flank of the Wolverine Anticline, about eight miles from the axis of the fold. It was clear that the oil rocks would lie rather shallow here, but by refraining from going further down the dip there was less risk of finding the beds occupied by water, and also there was less chance of failure to reach the desired horizons occasioned by engineering difficulties in such a remote country. The well was drilled during the summer of 1920. Almost from the start oil was coming into the hole; and before a depth of 100 ft. was reached, a yield of five or ten barrels a day could be obtained. After passing from the Camp Creek Series into the dark Fort Creek shales, the oil showings still continued, until at a depth of 783 ft. a strong flow of oil was encountered which spouted to a height of 70 ft. After about ten minutes the well was capped. Some hundreds of barrels of oil issued from the well before it was finally shut in, but no dependable estimate of its capacity can yet be made. It is thought that the initial output will be at least 500 barrels a day. Whether or not this first well will settle down as a steady, large producer yet remains to be seen. And, in any case, many more wells must be drilled before the importance of the field is fully proved.

Dr. Bosworth proceeded to give an outline of the geology of the region. The strata exposed in the Mackenzie oilfield district include:

Tertiary ...	Shales, sandstones, and lignites.
Cretaceous ...	Clay-shales and sandstones.
Devonian ...	Limestones, shales, and sandstones.
Silurian	Limestones, etc.

It is in the Devonian only that the oil and gas have been found. In the region containing the lower part of the Mackenzie River, from Fort Norman northward, the Devonian is divided provisionally by Dr. Bosworth into the following main groups:

		Thickness in ft.
Camp Creek Series.	Clay-shales and sandstones. Greenish and variegated. Marine shells and plant particles.	2,000+
Fort Creek Series.	Bituminous shales with thin seams of sandy limestone. Black, but in places burnt brick-red. Plants and marine shells.	500–1,000
Beavertail	Bituminous limestone beds. Black or dark. [illegible] and other marine fossils	350
Rampart Limestone.	Massive grey limestone. Many fossils, marine.	100–200
Hare River Shales.	Calcareous clay-shale. Grey-green. Few fossils, marine.	300
Barren Series	Brecciated dolomite and white, grey, and buff limestones, without fossils.	2,000 (?)

After passing Fort Norman, the river comes in contact with a mountain system, referred to as the Limestone Mountains. These mountains, which consist of anticlinal folds of Devonian rocks, are encountered by the river for a distance of a hundred miles. It is in this territory that the favourable indications and structural conditions were found, which have led to the recent strike of oil. This is the site of the new oilfield. A few miles beyond Fort Norman, the Mackenzie turns sharply to north-westward, so as to flow along the S.W. flank of the Limestone Mountain range. This straight course, known as the Long Reach, is maintained for 75 miles, parallel with the range, and a few miles from it. The river then turns northward, and in a distance of 25 miles it cuts across the trend of the mountains, at their western end. The Devonian strata of the Limestone Mountain district have been thrown into a series of bold asymmetrical folds, whose axes plunge up and down, steeply and frequently. In the synclines, the soft Camp Creek

series and Fort Creek shales give rise to low ground. But wherever the upward pitchings of the anticlinal axes bring the arches of the Beavertail limestone up above the general level of the land, the denudation has developed out the arches, as conspicuous anticlinal hills. Four main anticlines are thus revealed where the Mackenzie River crosses the folds. At this place all of them are pitching down toward the west. In order from south to north, they have been named by the author: Wolverine, East Mountain, Bat Hills, and Beavertail. Anticlinal structure in the region was first observed at Bear Mountain by R. G. McConnel, but the main folds were found and mapped by the author in 1914. The four axes lie roughly parallel, at intervals of about seven miles. Their direction, where the river crosses them, is slightly north of east; but on the east side of the river they bend round to a E.S.E. course, which is perhaps their more important direction. These four main anticlines are very much alike, each forming a line of more or less discontinuous limestone hills, exceeding 1,000 ft. in height. In each of these anticlinal ranges a core of the grey barren limestones, or the Fort Norman limestones, is laid bare in the parts where the axis rises to its maximum height. On each of them the bituminous Beavertail limestone forms steep dip-slopes; and generally it is also seen forming conspicuous arches on some parts of the crests. Low down on the flanks, the Fort Creek shales are found, followed by the soft Camp Creek beds. Near the axes, the strata at the core are very steeply inclined; but a mile or two away, on the flanks of the anticlines, the dip is 15° to 35°.

It was the remarkable character of the Fort Creek Shales and Beavertail Limestone, rather than the oil seepages, which led to a favourable view of the prospects in this field. For here, extending over a large region, there are 1,000 to 1,500 ft. of highly bituminous rocks, which obviously are a potential source for the generation of a great quantity of petroleum. These limestones and shales are black with bituminous material, which appears to be present, not as a migratory, but as a fixed constituent. In some places where these beds are much exposed, the bituminous odour is so strong that it may be noticed at a distance of half a mile. The bituminous shales are undergoing slow combustion at their outcrop, and often they are burnt to a bright brick-red colour, or even to a grey colour, becoming so hard that they clink when struck. In several localities there are conspicuous cliffs of these bright red rocks, over a hundred feet high. Fluid oil is not visible in the bituminous rocks, though where they pass under water some liberation of gas is seen. But oil might reasonably be expected in the porous beds of the overlying thick series of clay shales and sandstones, and also there was a good chance that at depth, and under favourable structure, accumulations of petroleum might occur within the black shales and limestones themselves. After study of the bituminous beds, the sands of the overlying Camp Creek Series were searched for oil. At each place examined, either seepages were found, or the presence of oil was detected on crushing the rock under water. The principal seepages occur on the shores of the Long Reach, where the river flows for seventy-five miles along the outcrop of the Camp Creek Series. Near the mouth of Camp Creek (which at first was called Oil Creek) the seepages are conspicuous for a distance of two and a half miles. On digging in the river gravel, the outcrops of the green oil-sands are exposed, and the oil could be collected in considerable amount. Further out in the river much oil rises up to the surface of the water, and in winter it collects, forming pools on the ice.

The oil has a paraffin base and is of high quality. The seepage oil, obtained on digging in the outcrop of the Camp Creek beds, has a greenish black colour, and a strong paraffin smell. The specific gravity is 0·905. The crude oil from the well is of light colour, low specific gravity, high gasoline content, and low cold test.

Dr. Bosworth's paper contains also a large amount of information as to the general stratigraphy, means of access and transport, the structure of the individual anticlines, and analyses of the oil.

Andean Geology.—At the meeting of the Geological Society of London held on April 29, J. A. Douglas read a paper entitled: "Geological Sections through the Andes of Peru and Bolivia, III, from Callao to the River Perene." This paper is the third of a series by the writer dealing with the geological structure of the Andes of Peru. The ancient rocks of the coastal Cordillera of the south are no longer met with in Central Peru, and the zone of Mesozoic rocks extends to the Pacific coast, which is here formed of shallow-water deposits of Lower Cretaceous age. The granodioritic batholith which forms the core of the Andes is encountered in the neighbourhood of Lima, and again almost at the summit of the range. The western flanks of the Cordillera are characterized by a great development of Cretaceous porphyritic agglomerate; while the normal calcareous facies is the dominant feature of the high-level regions. The intensity of the Tertiary folding has obscured the effects of the post-Jurassic uplift, previously shown to occur in the south, and it is only on palæontological evidence that a break in the sequence of Mesozoic deposits can be determined. Intrusions of andesite and dacite in the form of volcanic necks are of common occurrence; but there is no trace of recent volcanic activity in this area. The fossiliferous Devonian and Permo-Carboniferous deposits of the Titicaca district are not continued into the region here described. The rocks of Palæozoic aspect which form the eastern flanks of the Cordillera are, for the greater part, unfossiliferous, and have largely been converted into phyllites and mica-schists, penetrated by granite, which has also shared in the metamorphism. On the Rio Perene another and much bigger mass of red granite is met with. This is essentially a rock of alkaline character, as distinct from the calcite granodiorites of the Cordillera. It is suggested that its origin, like that of a similar rock in the coastal Cordillera of the south, dates from a very early period, antecedent to the uplift of the mountain-ranges.

In the discussion following the reading of the paper, Dr. J. W. Evans said that the comparison between the geology of this section across the Andes with those previously described was full of interest. He suggested that the change of strike from roughly north-west towards north-north-west was not without significance. Ultimately, still farther north, the strike became north and south. In a paper on the rocks of the Madeira Falls he, the speaker, had contended that the lines of folding in South America with a north-west and south east direction were older than those striking north and south, and this view was consistent with the facts adduced by the author of the paper just read.

Professor W. J. Sollas said the author had wisely abstained from entering upon hypothesis, but it would be interesting if he could inform them as to what he thought about the mechanism of mountain-building. In such a lofty range one might well have expected mighty overthrusts, some plains of Piedmont overriding the high Alps, but they were told of nothing worse than strata vertically upreared on end and some overfolds. The igneous intrusions were, however, on a grand scale, and it looked as though it might be necessary to make a partial return to hypotheses now out of date. Possibly

batholiths may have played a more important part than the opinions at present fashionable would concede.

The author, in reply to the discussion, said he fully agreed with Dr. Evans that much of the evidence tended to show that the folding was not contemporaneous throughout the length of the chain. In the Jurassic rocks, for example, deposition appeared to have ceased with the Lower Lias in the district now described; farther south it was continued into Bajocian times, while in the north of Chile beds of Oxfordian age were found. The transition of the fossiliferous, Cretaceous limestones of the north into the gypsiferous red sandstones of the south was also a significant feature. In reply to Professor Sollas, he said that the facts now recorded were in no way opposed to the views that he had previously expressed as to the nature of the processes which gave rise to the uplift of the Andes. The great granite mass of the Perene formed, with the nepheline-syenites of the Inambari district, one of the jaws of the vice that had compressed the transgressive deposits of the geosyncline. Fragments of the other jaw were to be found in the similar granite of the coastal Cordillera

SHORT NOTICES.

Drilling for Oil.—At the meeting of the Institution of Petroleum Technologists held on April 19, Alan W. Davson read a paper on the education and training of a driller.

Mine Atmospheres.—The March *Journal* of the South African Institution of Engineers contains a paper by A. J. Orenstein and H. J. Ireland on the effect of heat and moisture on workers in mines.

Roof Supports in Mines.—The *Iron & Coal Trades Review* for April 1 publishes an illustrated paper by Alfred Terrell on the best methods of supporting the roof and sides of roadways and working places in coal mines.

Ventilating Currents.—At the April meeting of the Mining Institute of Scotland, David Penman described a new method of measuring ventilating resistances, with special reference to the operation of mine fans in combination.

Shaft-Sinking.—At the April meeting of the Manchester Geological and Mining Society, Charles Walker read a paper describing his system of sinking shafts through wet ground, being a modification of the cementation process.

Mining Costs.—At the March meeting of the Institution of Mining and Metallurgy, A. E. Pettit presented a paper on "Notes and Records of Mining Costs."

Gunite.—In the *Engineering and Mining Journal* for March 26, G. J. Young writes on the application underground of gunite, that is to say, cement mixture put in place by an air-blast machine.

Cyaniding in Ecuador.—In the *Engineering and Mining Journal* for April 2, P. C. Schraps describes the cyanide plant at the Zaruma gold mine, Ecuador.

Electrolytic Zinc.—At the April meeting of the Faraday Society, Samuel Field read a paper on electrolytic zinc, recounting the work done by him at Swansea. We gave a notice of a previous paper by him in the issue of October last. Comment is made on this subject in *Engineering* for April 1.

Nickel-Copper Alloys.—In *Chemical and Metallurgical Engineering* for March 30, P. D. Merica discusses alloys of nickel and copper, particularly in connection with coinage alloys

Copper in Steel.—In *Chemical and Metallurgical Engineering* for March 30, E. A. and L. T. Richardson continue the discussion of the influence of copper on the physical properties of iron and steel.

Colorado Oil-Shales.—In *Chemical and Metallurgical Engineering* for March 30, A. J. Franks discusses distillation problems in connection with Colorado oil-shales.

Potash Alum and Sulphur In *Chemical and Metallurgical Engineering* for March 23, L. Duncan describes the recovery of potash alum and sulphur, occurring in rhyolitic tuffs at Tonopah, Nevada.

Feld's Ammonium Sulphate Process.—The *Chemical Trade Journal* for April 16 contains notes on the Feld direct process for producing ammonium sulphate at gas works. Reference to this process was made in the MAGAZINE for August, 1912.

Haber Ammonia Process.—In the *Journal* of the Society of Chemical Industry for March 31, J. R. Partington describes the operation of the Haber synthetic ammonia process as operated by the Badische Anilin & Soda Fabrik at Oppau.

Jarosite in Victoria.—*Chemical Engineering and Mining Review* (Melbourne) describes a deposit of jarosite, the basic sulphate of aluminium and potassium, near Anglesea, Victoria.

Gold in Victoria.—*Economic Geology* for March contains an article by N. R. Junner on the geology of the gold occurrences in Victoria

Oil Geology.—In *Economic Geology* for March, R. A. Mills discusses the relation of texture and bedding to the movements of oil and water through sands.

Phosphates in Pacific Islands.—The *Journal* of the Society of Chemical Industry for March 31 contains a report of a paper read by T. Steel before the Sydney section on the phosphate deposits of Nauru and Ocean Islands, in the Pacific Ocean.

The Pas, Manitoba.—The *Bulletin* of the Canadian Institute of Mining and Metallurgy contains a paper on the occurrence of gold at Herb Lake, The Pas district, Manitoba.

Peat Power in Germany.—The *Engineer* for April 22 describes the scheme for supplying electric power throughout Germany from seven generating stations where steam power is obtained by the combustion of peat

Conditions in Silesia.—In the *Colliery Guardian* for April 1, Edgar P. Rathbone gives his experiences during a recent visit to Upper Silesia.

RECENT PATENTS PUBLISHED.

☞ *A Copy of the specification of any of the patents mentioned in this column can be obtained by sending 1s to the Patent Office, Southampton Buildings, Chancery Lane, London, W C 2, with a note of the number and year of the patent*

14,794 of 1920 (144,276). W. TYRRELL, Seattle, U.S.A. Binder for briquetting ores consisting of diatomaceous earth, sulphate of soda, concentrated lye, and magnesium carbonate.

15,878 of 1920 (144,725). J. E. KENNEDY, New York. Combined ball and tube mill.

19,013 of 1920 (160,708). F. MILLIKEN, New York. An alloy consisting of copper, nickel, zinc, and iron, capable of resisting acids at high temperatures.

20,763 of 1919 (159,525). C. J GRACE, Truro. Machine for drying china-clay or other plastic material.

21,812 of 1919 (160,477). R. L. LLOYD, New York. Improvements in the Dwight-Lloyd sintering plant.

24,721 of 1919 (159,530). BRITISH OXYGEN CO., London. Improved furnace for reducing metals from oxides by the action of hydrogen.

26,136 of 1919 (159,537). ARMSTRONG, WHITWORTH & CO., Newcastle-on-Tyne. An alloy which is non-corrosive and has a high resistance to the action of steam, consisting of 82½% copper, 9½% aluminium, 5% manganese, and 3% iron.

27,561 of 1919 (135,179). A. KNOBLOCH and O. MANDL, Teplitz, Czecho-Slovakia. Boring machine for driving tunnels and levels.

28,228 of 1919 (159,942). H. J. THACKERAY, Chesterfield. Combined metal and wood pit-prop.

29,216 of 1919 (159,568). W. B. BALLANTINE, London. Making a pure ferro-chrome by removing carbon from crude ferro chrome by means of an oxidizing blast, and then adding a thermo-reduction mixture containing a chromium compound so as to adjust the desired chromium content.

29,293 of 1919 (137,513) and **29,539 of 1919 (149,927).** NEW JERSEY ZINC CO., New York. Improvement in the method of producing zinc oxide by the Wetherill intermittent process.

29,965 of 1919 (159,950). TRAYLOR ENGINEERING & MANUFACTURING CO., Allentown, Pennsylvania. Improved construction of gyratory crushers.

30,816 of 1919 (160,231). F. S. NEWALL, Newcastle-on-Tyne. Improved electric furnace for calcining magnesite.

30,884 of 1919 (159,659). J. R. BROADLEY, J. M. LEE, and L. STEVENS BURT, London. Centrifugal pump, illustrated as the Wilfley pump in the MAGAZINE for February.

30,950 of 1919 (159,659). J. J. COLLINS, Winsford, Cheshire. Purification of tin and the production of tin salts from crude tin.

31,359 of 1919 (160,254). J. M. and A. T. HOLMAN, Camborne. Machine for sharpening rock-drill steels.

32,132 of 1919 (160,554). S. O. COWPER-COLES, London. Method of stripping electrically deposited sheets of metal.

32,243 of 1919 (133,459). J. DELECOURT, St. Ghislain, Belgium. Improved method of drilling by percussion.

32,416 of 1919 (160,293). J. L. MENNELL and CHAS. BUTTERS & CO., LTD., London. Apparatus for giving a continuous indication of the density of a liquid as it flows through a tank and for delivering the liquid as it leaves the tank to one of a number of launders according to its density.

2,077 of 1920 (159,737). OSMOSIS CO., W. R. ORMANDY, and D. NORTHALL-LAURIE, London. Method of vitrifying china-clay deposited by osmosis.

4,976 of 1920 (139,195). V. GERBER, Zurich. Method of producing aluminium nitride.

10,756 of 1920 (160,373). GENERAL ELECTRIC CO., Schenectady, New York. Method of making filament for electric lamps containing 95% tungsten and 5% silicon.

17,388 of 1920 (145,709). FRIED. KRUPP, Essen, Germany. Making low-carbon ferro-chrome by blowing high-carbon ferro-chrome in a converter.

18,079 of 1920 (160,395). E. W. DAHL, London. Plant for manufacture of white lead.

19,202 of 1920 (160,114). T. H. OSWALD and A. D. D. BROWN, London. Plant for distilling oil from sandstone, shale, etc.

19,675 of 1920 (147,689). R. E. BEA, Paris. Electrolytic vat for producing sulphate of copper from copper waste and scrap.

20,078 of 1920 (148,168). H. SCHRANZ, Freiberg, Germany. Making concentrating surfaces of porous material through which air or water may pass upward.

26,523 of 1920 (156,472). J. RHEINBERG, London. Improved method of producing metallic surfaces on glass, consisting of platinum or metals of the platinum group, intended for use as mirrors.

NEW BOOKS, PAMPHLETS, Etc.

☛ Copies of the books, etc., mentioned below can be obtained through the Technical Bookshop of *The Mining Magazine*, 724, Salisbury House, London Wall, E.C.2.

Well-Boring for Water, Brine, and Oil. By C. ISLER. New Edition. Cloth, octavo, 212 pages, illustrated. Price 16s. net. London: E. & F. N. Spon, Ltd.

Storage of Petroleum Spirit and Calcium Carbide. By Major A. COOPER-KEY. Cloth, small octavo, 135 pages. Price 5s. net. London: Charles Griffin & Co., Ld.

Recent Practice in the Use of Self-contained Breathing Apparatus. By REX C. SMART. Cloth, octavo, 250 pages, illustrated. Price 15s. net. London: Charles Griffin & Co., Ltd.

Elementary Text-Book on Mechanical Drawing. By JOHN E. JAGGER. Cloth, quarto, 250 pages, illustrated. Price 15s. net. London: Charles Griffin & Co., Ltd.

Catalogue of the Collections in the Science Museum, South Kensington. Price 1s. net. This section of the catalogue describes the exhibits relating to mining and ore-dressing.

Geology of the British Empire. By F. R. C. REED. Cloth, octavo, 480 pages, illustrated. Price 40s. net. London: Edward Arnold.

West Australian Geological Survey, Bulletin 83. Geology and mineral resources of the north-west, central, and eastern divisions. By H. W. B. TALBOT and R. A. FARQUHARSON.

Aluminium and Bauxite. Published by the Imperial Mineral Resources Bureau. Price 9s. net.

Bismuth 1913 to 1919. Pamphlet published by the Imperial Mineral Resources Bureau. Price 6d

Thorium, Zirconium, and Rare-Earth Minerals, 1919. By W. T. SCHALLER. Published by the United States Geological Survey.

COMPANY REPORTS

Tharsis Sulphur & Copper.—This company has worked pyrites mines in the south of Spain since 1866. The headquarters are in Glasgow, and it has several works in this country where burnt pyrites is treated for the recovery of copper. The report for 1920 shows that 251,620 tons of ore was raised from the Calanas mine, and 62,298 tons from the Tharsis, making a total of 313,918 tons, as compared with 260,801 tons in 1919. The new Sierra Bullones open-cut at Tharsis is now yielding a steady supply of ore, and the North Lode will shortly be drawn upon for shipping ore. The metal works have been fully employed during the year, and the amount of material treated has been exceeded only twice in the history of the company. The net profit was £134,949, out of which £131,250 has been distributed as dividend, being at the rate of 15%. The total dividends since the beginning have been £10,999,057, and £2,729,109 has been written off property and plant account.

Mason & Barry.—This company has worked the San Domingos cupriferous pyrites mines at Mertola, Portugal, since 1853, and has made large profits. During the war the restriction of trade and shipping facilities seriously interfered with the business of the company. The report for 1920 shows that conditions have improved again. The amount of ore raised was 93,812 tons, as against 60,522 tons in 1919. The shipments, inclusive of washed pyrites, amounted to 226,739 tons, as against 41,827 tons in 1919. The profit was £67,685, out of which £46,293 was paid as dividend, being at the rate of 25%. The sum of £5,000 was placed to the

account of the staff pension fund.

Sons of Gwalia.—This company was formed in 1898 to work a gold mine near Mount Leonora, West Australia. Bewick, Moreing & Co. are the managers. The report for 1920 shows that 135,230 tons of ore was treated for a yield of 41,690 oz., realizing £255,234, of which £77,353 represented premium. The working profit was £60,257, from which has to be deducted £16,310 for taxes and £8,288 for depreciation. The dividend absorbed £16,250, being at the rate of 5%. As already reported, a fire destroyed most of the mill and treatment plant in January, and the stoppage of productive operations followed. The directors intend to rebuild the plant, and have placed £20,000 out of the year's profit to the account for continuing development and providing new plant. Satisfactory settlement has been made with the insurance companies.

Ooregum Gold.—This company belongs to the John Taylor group, and operates a gold mine in the Kolar district, Mysore State, South India. The report for 1920 shows that 153,350 tons of ore was treated, yielding 96,268 oz. of gold. The amount of ore treated was about the same as the year before, but the yield of gold was 5,834 oz. greater. This rise is accounted for by the policy adopted of working richer ore so as to provide funds for sinking the new shaft and for supplying new plant necessary for continuing work at depth. The gold realized £499,756, and the working profit was £226,017. The shareholders received £93,173, the dividend rates being 32½% on the preference shares and 22½% on the ordinary shares. There was written off for depreciation £18,000, and £33,182 for expenditure on the new circular shaft; while £50,000 has been allocated to mine equipment account. The ore reserve is estimated at 422,656 tons, a fall of 5,310 tons on the year. In the lowest levels of the mine, namely, the 61st and 62nd in Oakley's section, and the 59th to 62nd levels in Bullen's section, the lengths of ore are not so great as in the levels above, owing to intrusions of pegmatite, but the ore is of good quality.

Gopeng Consolidated.—This company was formed in 1912 as a consolidation of the Gopeng and New Gopeng, which had been operating alluvial tin properties in Perak, Federated Malay States, since 1892 and 1903 respectively. The object of the consolidation was to facilitate the financing of a scheme, undertaken conjointly with Kinta Tin Mines, Ltd., for bringing a new supply of water at higher pressure for use in hydraulicking from the Kampar river. The control of the company is in Redruth. James Wickett is chairman, and Osborne & Chappel are the engineers. The report for the year ended September 30 last shows that, owing to an unusual drought, less tin ground could be treated, the figure being 1,115,196 cu. yd., as compared with 1,423,283 cu. yd. during the previous year. The output of tin concentrate was 733½ tons, as compared with 836 tons the year before, and the yield per yard was 1·48 lb. as compared with 1·32 lb. The income from the sale of concentrate was £133,745, and the working cost was £43,736. Dividends and interest brought an income of £5,931. The total profit was £97,399, out of which £59,365 was distributed as dividend, being at the rate of 15 per cent.

Tekka-Taiping.—This company was formed in 1913 as a subsidiary of the Tekka for the purpose of acquiring an alluvial tin property at Taiping in the Larut district of Perak, Federated Malay States. James Wickett is chairman, and Osborne & Chappel are the engineers. Operations were started with a pump-dredge, but a bucket-dredge was substituted later. A second bucket-dredge is on order. The report for the year ended October 31 last shows that 892,020 cu. yd. of ground was treated, for a yield of 394·9 tons of tin concentrate, being at the rate of 0·99 lb. per yard. The income was £70,023, and the working profit was £43,802, out of which £17,433 was paid as dividend, being at the rate of 5%. The allowance for depreciation of plant was £5,000, and a large balance was kept in hand pending settlement of liability for taxation. The yield from the ground treated was much higher than the calculated contents, the bore-hole figures calling for only 0·63 lb. per yard.

Rambutan.—This company belongs to the Wickett group, of Redruth, and was formed in 1905 to work alluvial tin ground in the northern part of the Kinta district, Perak, Federated Malay States. A pump-dredge was used at first, but hydraulic elevating was adopted afterwards. The report for the year ended June 30, 1920, shows that 212 tons of tin concentrate was extracted from 504,752 cu. yd. of ground, being a yield of 0·95 lb. per yard. The income from the sale of concentrate was £40,355, and the working profit was £25,403, out of which £15,000 was distributed as dividend, being at the rate of 15 per cent.

Pengkalen.—This company belongs to the Wickett group, of Redruth, and was formed in 1907 to work alluvial tin ground at Lahat, in the state of Perak, Federated Malay States. At first an electrically-driven pump-dredge was installed, but it did not give good results. A bucket-dredge is on order, and in the meantime the property has been let on tribute. A substantial income is at present realized by the sale of electric power to other mining companies, and this electric plant is being extended. The report for the year ended September 30 last shows that the income from tribute was £6,473, and from the sale of power £27,926, while £1,450 was received as dividends from investments. The costs at the mine and power plant were £19,789, and the working profit was £15,412, out of which £5,000 was written off for depreciation of plant, while £7,088 was distributed as dividend, being 15% on the preference shares and 5% on the ordinary shares.

Chendai Consolidated.—This company belongs to the Wickett group, of Redruth, and was formed in 1914 as a consolidation of the Redhills, Sungei Chendai, and the Chendai Lodes companies, operating in the Kinta district of Perak, Federated Malay States. The report for the year ended April 30, 1920, shows that the lode property was not worked owing to deficiency of available ore, and that the ore in the bottom level could not be mined owing to water in the stopes. A small amount of development work was done. The alluvial properties were let to tributers, who won 37 tons of tin concentrate, selling for £5,782, of which £780 accrued to the company as tribute. The company's accounts for the year show a loss of £823.

Plymouth Consolidated Gold Mines.—This company was formed in 1914 by Bewick, Moreing & Co. to acquire a gold mine, reported on by W. J. Loring, in Amador County, California. Dividends were paid regularly from 1915 to 1919. The report for 1920 shows that owing to unavoidable curtailment of development during preceding years, the tonnage of ore treated showed a decrease, being 91,350 tons as compared with 119,200 tons during 1919. The yield of gold was £121,799 as compared with £148,666; and the yield per ton 26s. 8d. as compared with 24s. 11d. per ton. As the mine is in the United States, no premium is received on the sale of gold. The working cost was £110,614, and after allowance for depreciation and American taxes, the total cost was £122,382, leaving a balance of profit of £2,358. The working cost per ton was 24s. 2d., as compared with 18s. 9d. in 1919, and 16s. in 1918. The advance in cost was due to increased wages and

prices of materials. The development done during the year has given satisfactory results. The No. 2 South ore-shoot was developed at the 1,500 and 1,600 ft. levels where, although the shoot was narrow, high values were disclosed, and the main and north foot-wall ore-shoots were opened up with good results at the 2,600 and 2,750 ft. levels respectively. At the 2,900 ft. level high-grade ore was developed, which it is believed forms the apex of a new shoot subsequently opened up at the 3,050 ft. level where, for a length of 204 ft., it averaged 57s. per ton over a width of 80 in. A winze from the latter level was sunk 50 ft. in ore averaging 54s. 6d. per ton over an exposed width of 92 in. The shoot was also intersected by a cross-cut from the shaft at the 3,120 ft. level, and averaged 33s. 6d. per ton over a width of 108 in. To expedite the opening up of this new ore-body the winze mentioned is being continued concurrently with shaft-sinking, and it is expected that when work has advanced sufficiently to enable the concentration of mining operations on this section, an improvement will result, not only in the output, but also in working costs.

Santa Gertrudis.—The report of this company, which works silver mines at Pachuca, Mexico, shows that during the year ended June 30, 1920, 356,753 tons of ore from the Santa Gertrudis and 120,322 tons from the El Bordo group were treated, for an extraction of 4,430,433 oz. of silver and 23,070 oz. of gold. The net profit was £237,384, of which £65,000 was allocated to income tax, while £150,000 was distributed as dividend, being at the rate of 10%. Developments at the Santa Gertrudis mine continue to give little result, and the reserve is estimated at 476,678 tons with recoverable contents of 4,309,556 oz. of silver and 24,382 oz of gold. At the El Bordo group, developments at the El Bordo property have given good results and the reserve has been substantially increased, standing now at 1,064,180 tons, the recoverable content being estimated at 11,000,000 oz. of silver and 48,400 oz. gold. At the Malinche mine development has been continued, but more work will have to be done before the value of the deposit can be ascertained. The reserve is estimated at 102,810 tons, containing 832,190 oz. silver and 3,670 oz. gold recoverable. Transport connection has been made with the El Christo mine, and shipments have commenced. The reserve is estimated at 147,750 tons, containing 1,188,300 oz. silver and 5,225 oz. gold recoverable. The company owns 250,000 £1 shares and £70,000 seven-year notes in the Mexican Corporation; also 49,996 £1 shares in the Mexican Chemical & Metallurgical Corporation, which was formed in January, 1920.

Camp Bird.—The report of this company for the year ended June 30, 1920, shows that the exploration conducted upward by means of the long tunnel has been continued, but that no important runs of gold ore have been discovered. The company received £58,917 as dividend on its holding in Santa Gertrudis, and made a profit of £50,320 by realization of certain investments. The accounts show a profit of £29,451. Dividends on the preference shares declared for the year absorbed £45,473. The company has subscribed for 100,000 £1 shares in the National Mining Corporation, and for 250,000 £1 shares and £70,000 seven-year notes in the Mexican Corporation; also for 24,998 £1 shares in the American Chemical & Metallurgical Corporation, which was registered in January, 1920.

Mexican Corporation.—This company belongs to the Camp Bird group, and was formed in July, 1919, to work the Fresnillo silver mine in Zacatecas, and the Teziutlan copper mine in Puebla. The company's interest in these mines is that it is supplying money for reorganizing and extending the scale of operations in return for 40% and 37½% respectively of the net profits. The company has also invested funds in the National Mining Corporation, and the Burma Corporation; it has a share in the Union en Cuale option obtained by the Esperanza company; and it holds an interest in the British Equatorial Oil Company. The report now issued covers the period from the formation of the company to the end of June, 1920. It is here stated that £999,396 had been dispatched to Mexico for capital purposes by December 31, 1920. Particulars are also given of the development work. At the Fresnillo mine there are two separate workings, one in an oxidized surface ore-body, and the other a system of deeper workings containing complex sulphide ore. The surface ore-body is estimated to contain 4,000,000 tons of ore which is easily treated by cyanide. The sulphide ore will probably have to be submitted to some concentration process before treatment. During the period November 1, 1919, to June 30, 1920, there was treated 100,901 tons from the surface ore-body, from which 390,744 oz. silver and 531 oz. gold were extracted. Also 96,225 tons of old tailing was treated, yielding 180,141 oz. silver and 428 oz. gold. At the Teziutlan property concentration plant has been erected, having for its chief object the removal of the zinc from the copper ore. During the period above-named, 35,256 tons of ore and concentrate was smelted, and the blister copper produced contained 2,199,692 lb. copper, 829 oz. gold, and 58,451 oz. silver.

Randfontein Central.—This company owns property in the farthest west Rand. The control passed a few years ago from J. B. Robinson to the Barnato group, under whose auspices the underground work was entirely reorganized. The report for 1920 shows that 1,561,330 tons of ore, averaging 5·62 dwt. per ton, was raised and sent direct to the mill. The yield of gold by amalgamation was 240,099 oz., and by cyanide 170,714 oz., making a total of 410,813 oz., equal to 5·26 dwt. per ton. The revenue from the sale of gold was £2,300,695, of which about £550,000 came from premium. The working cost was £2,142,595, leaving a working profit of £158,100. Against this profit was charged £138,580 for debenture interest, and £34,769 for interest on the loan advanced by the controlling house. The revenue per ton was 29s 5d., and the working cost 27s. 5d. The ore reserve is estimated at 3,593,410 tons, averaging 6·2 dwt. per ton. Of the two new main vertical shafts, the northern is already in commission, and the southern will be ready in July or August. The new development work has disclosed ore, in addition to the proved reserves, which is likely to last for many years.

Durban Roodepoort Deep.—This company belongs to the Central Mining-Rand Mines group, and was formed to work a deep-level property in the middle west Rand in 1895. The report for 1920 shows that 308,713 tons was raised, and after the rejection of 10% waste, 277,200 tons was sent to the mill. The yield of gold by amalgamation was 62,337 oz., and by cyanide 26,533 oz., making a total of 88,870 oz., or 6·4 dwt. per ton. The revenue from the sale of gold was £490,620, of which £112,900 represented premium. The working cost was £476,937, leaving a working profit of £13,682. The revenue per ton was 35s. 5d., and the working cost 34s. 5d. The development during the year was restricted owing to the shortage of labour, but the results obtained were good, 196,200 tons averaging 7·1 dwt. per ton being proved. The reserve is estimated at 1,094,900 tons averaging 6·6 dwt. per ton. During the first half of the year, when the gold premium was low, operations were being carried on at a loss, and the directors deemed it advisable to stop the sinking of the new vertical shaft, which had reached a depth of 2,272 ft. This shaft is necessary if working costs are

to be reduced, and the directors are now considering the advisability of resuming sinking.

Langlaagte Estates & Gold.—This company belongs to the Barnato group and works an outcrop property in the western portion of the central Rand. The report for 1920 shows that 465,300 tons averaging 6·2 dwt. per ton was mined and sent direct to the mill. The yield of gold by amalgamation was 83,181 oz., and by cyanide 55,592 oz., being a total of 138,773 oz., or 5·96 dwt. per ton. The revenue from the sale of gold was £774,031, of which £184,000 represented premium, and the working profit was £153,352. The revenue per ton was 33s. 3d. and the working profit 6s. 7d. The shareholders received £88,650, the dividends (Nos. 59 and 60) totalling 10%. Development has continued to give satisfactory results. The ore reserve is estimated at 1,016,800 tons averaging 6·4 dwt. per ton.

Consolidated Langlaagte Mines.—This company belongs to the Barnato group, and operates a deep-level mine in the western part of the central Rand. The report for 1920 shows that 484,247 tons of ore was raised and sent direct to the mill, together with 19,653 tons taken from the dumps. The average assay-value of the ore treated was 6·1 dwt. per ton. The yield of gold by amalgamation was 104,716 oz., and by cyanide 39,853 oz., making a total of 144,569 oz., or 5·74 dwt. per ton. The revenue from the sale of gold was £806,076, of which about £190,000 represented premium. The working profit was £185,109. The revenue per ton was 31s. 11d., and the working profit 7s. 4d. The shareholders received £118,750, the dividends (Nos. 13 and 14) being together 12½%. Developments in the bottom levels were very discouraging. The ore reserve is estimated at 1,339,000 tons, averaging 6·2 dwt., as compared with 2,090,300 tons of the same tenour last year. The fall in the reserve is due not only to poor developments, but also to some of the ore in the Leader proving of lower grade than originally estimated.

Village Deep.—This company belongs to the Central Mining-Rand Mines group and works a deep-level property in the central Rand to the west of City Deep. The report for 1920 shows that 604,686 tons of ore was raised, and after the removal of 8% waste, 555,800 tons averaging 6·63 dwt. per ton was sent to the mill. The yield of gold by amalgamation was 113,039 oz., and by cyanide 60,187 oz., making a total of 173,226 oz., or 6·23 dwt. per ton. The gold was sold for £956,921, of which about £220,000 represented premium. The working cost was £828,339, leaving a working profit of £128,581. The revenue per ton was 34s. 5d., the cost 29s. 10d., and the profit 4s. 7d. The shareholders received £106,067, the dividends being at the rate of 10%. The development during the year gave fairly good results, and 533,700 tons averaging 6·3 dwt. per ton was proved. The reserve is estimated at 2,381,200 tons averaging 6·1 dwt. per ton; of this amount, 508,900 tons averaging 5·9 dwt. is in pillars. The main incline shaft has been sunk to the 32nd level, and is now 6,059 ft vertically below the outcrop.

City Deep.—This company belongs to the Central Mining-Rand Mines group, and works a deep-level property in the central Rand. The report for the year 1920 shows that following on the absorption of the City & Suburban it was possible to increase the native labour supply. Consequently a much larger amount of ore was milled. In fact, for the first time in the history of the mine, it was possible to work the mill at full capacity. The amount milled was 862,500 tons, compared with 617,800 tons in 1919 and 670,000 tons in 1918. The assay-value of the ore milled was 8·45 dwt. per ton. The yield of gold by amalgamation was 252,828 oz., and by cyanide 98,533 oz., making a total of 351,361 oz., or 8·14 dwt. per ton milled. The income from the sale of gold was £1,951,330, of which about £458,000 was due to premium, the average price obtained for the gold being 111s. per oz. The revenue per ton was 45s. 3d. The working cost was £1,301,981, or 30s. 2d. per ton, leaving a working profit of £649,348, or 15s. 1d. per ton. Dividends absorbing £415,250 were distributed, being at the rate of 32½%. The profit was £191,661 higher than that for 1919. The cost per ton has continued to increase, and compares with 27s. 9d. in 1919 and 24s. 8d. in 1918. The developments have not been quite as good as they were during the previous few years; nevertheless 598,500 tons averaging 8·9 dwt. was proved. The reserve is estimated at 3,099,200 tons averaging 9 dwt. per ton, as compared with 3,418,452 tons averaging 9·4 tons the year before. The sinking of the new shaft near the southern boundary, which will be 7,000 ft. deep, has been described in a paper by E. H. Clifford, quoted in our March issue.

Crown Mines.—This company belongs to the Central Mining-Rand Mines group, and works deep-level ground in the central Rand. The report for 1920 shows that 2,254,583 tons of ore was raised, of which 1,342,676 tons came from the Main Reef Leader, 949,731 tons from the South Reef, and 150,965 tons from the Main Reef. After the removal of 10% waste, 2,201,000 tons, averaging 6·35 dwt. per ton, was sent to the mill. The yield of gold by amalgamation was 496,589 oz., and by cyanide 175,016 oz., making a total of 671,605 oz., equal to 6·1 dwt. per ton. The par value of the gold was £2,872,542, equal to 26s. 1d. per ton. To this must be added £926,062 accruing from premium, equal to 8s. 5d. per ton. The total revenue was thus £3,704,273, equal to 33s. 8d. per ton. The working cost was £2,611,137, or 23s. 9d. per ton, leaving a working profit of £1,093,335, or 9s. 11d. per ton. The shareholders received £728,582, the dividend being at the rate of 77½%. The reserve is estimated at 8,131,700 tons, averaging 6·4 dwt. per ton, of which 4,972,800 tons, averaging 6·9 dwt., is in the Main Reef Leader, and 3,158,900 tons, averaging 5·4 dwt., is in the South Reef. Of this total, 1,289,000 tons, averaging 7·3 dwt., is in pillars and is not immediately available for stoping. The development of the large area below the 19th level is being actively conducted. No. 5A shaft has been sunk 1,573 ft. vertically below the 19th level main haulage east, and is now in readiness for the development of the area north-east of the South Rand dyke. Preparations are in hand for the sinking of No. 14A shaft below No. 14 vertical shaft, situated 2,000 ft. south of No. 5A shaft. This shaft is intended for the exploitation of the south-eastern part of the company's ground. The sinking of No. 15 shaft in the western section has been completed to the requisite depth, and the sub-shaft No. 15A is now in hand. The two shafts Nos. 14 and 15, with their continuations in depth, Nos. 14A and 15A, will be used in developing the extensive ground in the southern part of the property.

Meyer & Charlton.—This company belongs to the Albu group and works an outcrop gold mine in the central Rand. The report for 1920 shows that the remarkable prosperity of this comparatively small mine has continued, and owing to the premium has made a bigger profit than ever. The reserve of rich ore is, however, limited. During the year, 160,150 tons of ore averaging 13·16 dwt. per ton was mined and sent to the mill. The yield of gold by amalgamation was 39,649 oz., and by cyanide 45,010 oz.; in addition 17,503 oz. was extracted from concentrates. The total yield was 102,163 oz., equal to 12·77 dwt. per ton. The revenue from the sale of gold was £566,563, of which about

£133,000 came from premium. The working cost was £221,469, and the working profit £345,093. The revenue per ton was 70s. 9d., the working cost 27s. 7d., and the working profit 43s. 1d. The shareholders received £240,000, the dividends (Nos. 61 and 62) totalling 120%. The ore reserve is estimated at 450,050 tons averaging 14·1 dwt. per ton, as compared with 516,489 tons averaging 15·5 dwt. These figures do not include ore in pillars and hanging and foot-wall reefs; 54,555 tons was drawn from these sources during the past year

Geldenhuis Deep.—This company has worked a deep-level property in the near east Rand since 1893, and in later years absorbed the Geldenhuis outcrop mine. The control is with the Central Mining-Rand Mines group. The report for 1920 shows that 598,435 tons was raised, and after the rejection of waste, 557,500 tons averaging 5·93 dwt. per ton was sent to the mill. The yield of gold by amalgamation was 104,101 oz., and by cyanide 52,093 oz., making a total of 156,194 oz., or 5·6 dwt. per ton. The revenue from the sale of gold was £861,944, of which £189,000 was premium. The working cost was £777,053, leaving a working profit of £84,891. The revenue per ton was 30s, 11d., the working cost 27s. 11d., and the working profit 3s. The shareholders received £87,862, the dividends being at the rate of 15%. The ore reserve is estimated at 1,467,100 tons averaging 6·1 dwt. per ton. Ore continues to be exposed in the western section of the mine, though of limited extent. In the eastern section many falls have taken place, and it is a question how long ore can be extracted safely. The life of the mine depends also on the gold premium.

Knight Central.—This company has worked a deep-level property in the middle east Rand since 1903, but little profit has ever been made. The control passed from Neumann's to the Central Mining-Rand Mines group three years or so ago. During the last two years the mine has been on the point of ceasing work on more than one occasion, but the gold premium together with new discoveries of limited extent have postponed the evil day. The report for 1920 shows that 295,100 tons of ore averaging 6·16 dwt. per ton was mined and sent direct to the mill. The yield of gold by amalgamation was 49,635 oz., and by cyanide 36,385 oz., making a total of 86,020 oz. or 5·83 dwt. per ton. The gold realized £470,697, of which about £108,000 represented premium. The working cost was £402,097, leaving a working profit of £68,600. The revenue per ton was 31s. 11d., the working cost 26s. 10d., and the working profit 4s. 8d. The shareholders received £67,500, being at the rate of 7½%. This is only the second dividend ever paid. During the year, 120,000 tons of ore averaging 5·9 dwt. per ton was exposed, and at the end of the year the reserve was estimated at 150,700 tons averaging 6·1 dwt. The development of the area south of the Simmer dyke between No. 4 and No. 5 incline shafts has given uniformly poor results. As regards the eastern part of the mine, further development would involve a large expenditure on a new incline shaft, and this expenditure is not considered to be warranted. The exploration of the large area on the dip could only be done by means of a new vertical shaft, which would cost far more than the funds at the company's disposal, and it would not be warranted by the prospects. It is not likely that the mine will survive the current year.

Witwatersrand Gold.—This company belongs to the Barnato group and works the Knight's mine in the middle east Rand. The report for 1920 shows that 463,055 tons of ore was delivered to the sorting station, and after the removal of 10% waste, 416,200 tons, averaging 5·8 dwt. per ton was sent to the mill. The yield by amalgamation was 87,615 oz., and by cyanide 29,011 oz., making a total of 116,626 oz., or 5·6 dwt. per ton. The revenue from the sale of gold was £650,133, of which £145,000 represented premium, and the working profit was £133,757. The revenue per ton was 31s. 3d., and the working profit 6s. 5d. The shareholders received £93,925, the dividends (Nos. 32 and 33) totalling 20%. The ore reserve is estimated at 774,500 tons averaging 6 dwt. per ton, as compared with 1,142,500 tons averaging 5·9 dwt. the year before. The sinking of the southern incline shaft has been stopped at a depth of 3,353 ft. as the prospects in the bottom of the mine are not promising. Toward the end of the year 47 claims were acquired from Knights Deep. It is hoped to obtain from these claims a substantial tonnage of ore which will help to keep the battery more fully employed than it otherwise would be.

Witwatersrand Deep.—This company used to belong to the Central Mining-Rand Mines group, but two years ago local shareholders obtained control. The report for 1920 shows that 369,597 tons of ore was raised, and this, together with 20,208 tons of low-grade ore from the dumps, was sent to the sorting station, where 5,885 tons of waste was removed. The ore milled was 383,800 tons averaging 5·53 dwt. of gold per ton. The yield of gold by amalgamation was 72,190 oz., and by cyanide 29,599 oz., making a total of 101,789 oz. The revenue from the sale of gold was £557,104, of which £136,404 came from premium. The working cost was £492,267, leaving a working profit of £64,837. The revenue per ton was 29s., the cost 25s. 8d., and the profit 3s. 4d. No dividend is paid, as funds are required for development and improvement in underground facilities. During the year the reserve has been increased from 922,639 tons averaging 6·4 dwt. to 1,018,390 tons averaging 6·3 dwt. The results obtained on the 24th level were on the whole disappointing, but conditions on the 25th level are better.

New Kleinfontein.—This company belongs to the Anglo-French Exploration group and works a group of outcrop mines in the Far East Rand. The report for 1920 shows that 667,392 tons of ore was raised, of which 93,070 came from the Benoni section, 16,652 tons from the Apex, and the remainder from the Kleinfontein. After the removal of 15% waste, 561,820 tons, averaging 6·08 dwt. per ton, was sent to the mill. The yield of gold by amalgamation was 104,212 oz., and by cyanide 57,665 oz., making a total of 161,877 oz., equal to 5·76 dwt. per ton. The revenue from the sale of gold was £875,490, or 31s. 2d. per ton, of which about £187,500 represented premium. The working cost was £798,991, or 28s. 5d. per ton, leaving a working profit of £76,498, or 2s. 9d per ton The shareholders received £57,577, the dividend being at the rate of 5%. The ore reserve is estimated at 1,623,574 tons, averaging 5·32 dwt per ton, as compared with 1,923,474 tons, averaging 5·61 dwt. the year before. In the Apex section, which is now closed, the reserve is estimated at 374,997 tons, averaging 4·98 dwt. The Apex mill is leased to Modderfontein East.

Modderfontein B.—This company belongs to the Central Mining-Rand Mines group and operates a gold mine in the Far East Rand. The report for the year 1920 shows that 614,736 tons was raised, and with 15,545 tons from the dumps, was sent to the sorting station. After the removal of 14% waste, 627,700 tons averaging 10·2 dwt. per ton was sent to the mill. The extraction of gold by amalgamation was 179,343 oz., and by cyanide 132,874 oz., making a total of 312,217 oz., or 9·95 dwt. per ton milled. The revenue from the sale of gold was £1,736,750, of which £438,304 came from premium. The working cost was £818,326, leaving a

working profit of £[illegible]18,423. The revenue per ton was 55s. 4d., of which 14s. represented premium, the cost 26s. 1d., and the profit 29s. 3d. The shareholders received £577,500, the dividends (Nos. 16 and 17) being at the rate of 82½%, while £144,814 was allocated to capital expenditure, chiefly on the two new southern shafts. The ore reserve is estimated at 3,006,600 tons averaging 8·6 dwt. per ton, as compared with 3,215,100 tons averaging 9 dwt. the year before. Development work has proved that much of the ground in the north-east area is disturbed by faults and dykes and unpayable. Most of the profitable ore exposed during the year was in the south-west area. The new south-east shaft was sunk to the reef, which is much disturbed here. Connection will be made with the rise put in from the Geduld in the south-east corner, where the ground is also disturbed, though a promising ore-body has been found. The south-west shaft is in course of sinking.

Government Gold Mining Areas (Modderfontein).—This company belongs to the Barnato group and works a gold mine in the Far East Rand. The report for 1920 shows that 1,763,913 tons of ore was raised, and after the rejection of 14% waste, 1,515,000 tons averaging 8·3 dwt. per ton was sent to the mill. The yield of gold by amalgamation was 335,563 oz., and by cyanide 267,676 oz., making a total of 603,239 oz., or 7·96 dwt. per ton. The revenue from the sale of gold was £3,314,749, of which about £750,000 represented premium. The working profit for the year was £1,708,163. The revenue per ton was 44s. 9d., and the working profit 22s. 6d. The Government's share of the profits was £882,975, and £700,000 was distributed among shareholders, the dividends (Nos. 6 and 7) being 50% for the year. Development during the year has given excellent results. The reserve is estimated at 10,291,000 tons averaging 8·2 dwt per ton. Arrangements are in hand for making the south east shaft an upcast so as to improve the ventilation. Eventually it is expected that another shaft will have to be sunk for ventilation purposes only.

Van Ryn Deep.—This company belongs to the Barnato group, and works a gold mine in the Far East Rand. The report for 1920 shows that 750,606 tons of ore was raised, and after the removal of 22% waste, 583,950 tons averaging 10·58 dwt. per ton was sent to the mill. The yield of gold by amalgamation was 198,387 oz., and by cyanide 107,441 oz., making a total of 305,824 oz. The revenue from the sale of gold was £1,677,474, of which about £375,000 represented premium. The working profit was £964,883. The revenue per ton was 54s. 6d., and the profit 33s. The shareholders received £777,979, the dividends (Nos. 14 and 15) amounting to 65%. The ore reserve is estimated at 3,260,000 tons, averaging 9·7 dwt. per ton. Development has recently been pushed in the western section of the mine, which has hitherto been neglected owing to the prospects being considered unpromising. The results have been encouraging, for though the ore is not of high assay value, still it is payable, and the reef widths are considerable.

Modderfontein Deep Levels.—This company belongs to the Union Corporation (formerly Goerz) group, and operates a gold mine in the Far East Rand. The report for 1920 shows that 635,414 tons of ore was mined, and after the removal of 20% waste partly below ground and partly on the surface, 507,700 tons averaging 10·82 dwt. per ton was sent to the mill. The yield by amalgamation was 171,524 oz., and by cyanide 96,348 oz., making a total of 267,872 oz., or 10·55 dwt. per ton. The revenue from the sale of gold was £1,466,594, of which £327,634 represented premium. The working cost was £575,287, and the working profit £891,307. The revenue per ton was 57s. 9d., the working cost 22s. 8d., and the working profit 35s. 1d. The shareholders received £725,000, the dividends being at the rate of 145%. As compared with the previous year, the revenue was 9s. 6d. per ton higher, the costs 4s. 3d. higher, and the profit 5s. 3d. higher. The reserve is estimated at 4,100,000 tons averaging 9·4 dwt. per ton, as compared with 3,775,000 tons averaging 9·1 the year before. A larger proportion of waste is now sorted out than formerly.

Geduld Proprietary Mines.—This company belongs to the Union Corporation (formerly Goerz) group, and works a gold mine in the Far East Rand. The report for 1920 shows that 637,276 tons of ore was mined, and after the rejection of 15% waste, 527,800 tons, averaging 7·63 dwt. per ton, was sent to the mill. The yield by amalgamation was 83,937 oz., and by cyanide 102,993 oz., making a total of 186,930 oz., or 7·1 dwt. per ton. The income from the sale of gold was £1,023,953, and the working cost £635,283, leaving a working profit of £388,673. The premium on gold accounted for £229,259. The yield per ton was 38s. 10d., the working cost 24s. 1d., and the working profit 14s. 9d. The shareholders received £205,296, the dividends being at the rate of 17½%. The developments have given good results, especially in No. 7 level east from No. 3 shaft toward No. 7 shaft, where a large amount of very high grade ore has been found. The reserve is estimated at 3,220,000 tons, averaging 8 dwt., as compared with 2,580,000 tons, averaging 7·4 dwt., the year before.

Brakpan Mines.—This company belongs to the Consolidated Mines Selection group, and has worked a gold mine in the Far East Rand since 1903. The report for 1920 shows that 699,019 tons of ore was raised, and after the removal of 14½% waste, 597,100 tons averaging 8·85 dwt. per ton was sent to the mill. The yield of gold by amalgamation was 174,446 oz., and by cyanide 79,219 oz., making a total of 253,665 oz., equal to 8·5 dwt. per ton. The par value of the gold was £1,087,614, or 36s. 5d. per ton, and the premium brought an additional income of £336,164, or 6s. 11d. per ton. The working cost was £881,393, or 29s. 6d. per ton, leaving a working profit of £542,385, or 18s. 2d. per ton. Shareholders received £380,190, the dividends (Nos. 17 and 18) totalling 45%; £25,000 was placed to reserve for reorganization of plant and equipment, and £125,000 was allocated to expenditure on the new leased area. The ore reserve is estimated at 2,526,517 tons averaging 8·88 dwt. per ton, as compared with 2,484,000 tons averaging 8·74 dwt. the year before.

Springs Mines.—This company belongs to the Consolidated Mines Selection group, and was formed in 1909 to work gold-mining property in the Far East Rand. The report for 1920 shows that 569,963 tons of ore was raised, and after the removal of 18½% waste, 465,800 tons averaging 9·58 dwt. per ton was sent to the mill. The yield of gold by amalgamation was 97,293 oz., and by cyanide 110,843 oz., making a total of 208,136 oz. The par value of the gold was £881,421, or 37s. 10d. per ton, and the premium realized £271,503, or 11s. 8d. per ton. The working cost was £714,436, or 30s. 8d. per ton, and the working profit was £438,487, or 18s. 10d. per ton. The shareholders received £251,372, the dividends (Nos. 3 and 4) totalling 20%. The ore reserve is estimated at 2,726,178 tons averaging 8·76 dwt. per ton, as compared with 2,417,298 tons averaging 8·74 dwt. the year before. The increase is due chiefly to the further excellent development of the large ore-shoot in the east haulage area in the South Shaft district, but is also due to good results in the area contiguous to the north-west haulage.

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EDITORIAL

THE coal strike has caused the power engineers to turn their attention to oil once more, and some of the railways and electric stations are thereby enabled to carry on. The Government has announced that all new ships built for the Navy are to use oil-fuel.

WE would draw attention to a communication, printed elsewhere in this issue, in which Messrs. H. W. Hutchin and Stanley B. White appeal for subscriptions to the Camborne Memorial to old students who fell in the war. Some particulars of the Memorial were given in our issue of January last.

AFTER having served its purpose well for twenty years, the Charters Towers School of Mines is to be dissolved. Owing chiefly to the decay of the local goldfield, but partly also to the general depression of mining operations in Queensland, there is little demand now for facilities in connexion with mining education. In future, such instruction will be given at the Charters Towers Technical College. During its comparatively short existence, the influence of the school has been felt throughout Australia, and its graduates have made good in many important positions.

PUBLISHERS of and subscribers to technical journals and proceedings of scientific societies were naturally alarmed at the proposal of the bureaucratic deadheads of St. Martin's Le Grand to double the postage on printed matter sent abroad. Fortunately the Government defeat in the Westminster election supervened, and the obnoxious decree has been withdrawn. The Postmaster-General, seeing the signs of the times, has appointed a committee of active business men of acknowledged standing, with whom he will confer before proposing any more modifications of the postal service. This is a distinct improvement in public policy.

A MILD sensation was caused last month by the announcement in the daily press that a Hatton Garden pearl merchant had been deceived by artificial pearls grown in Japan. The fact is that this "culture" has been known to scientists and to the market for some years. Mr. K. Mikimoto, the pioneer of this work, published a description and diagram of the process in his catalogue, and Dr. Lyster Jameson described it at the meeting of the British Association held in Dundee in 1912. Briefly described, the process consists of inserting a bead of mother-of-pearl in the oyster in a particular way and allowing the oyster to do the rest. We are not sufficiently versed in the art of casuistry to care to argue whether these pearls are really "pearls" or not.

ATTENTION is once more being drawn to Greenland and its possible resources by the celebration of the two hundredth anniversary of the foundation of a Danish colony there by Pastor Egede. The presence of the King and Queen of Denmark at Godthaab, Egede's little settlement, will serve to renew interest in the northerly outposts of civilization. Much is heard of Spitsbergen, and the coal deposits in Iceland have been the subject of discussion recently. The only mineral at present worked in Greenland is cryolite, which is required as a solvent for alumina in the electric production of aluminium. But most of Greenland is covered with the glacial cap and only a small coastal fringe is available for prospecting.

IT is surprising to hear that the Institution of Electrical Engineers is not yet in possession of a Royal Charter. In these days it is hardly possible for the casual observer to believe that electricity is a new thing, any more than a mining engineer can realize without reflection that Johannesburg had no railway communications until 1892. The Institution was formed originally as the Society of Telegraph Engineers, and in those days it applied for a charter. This application was, of course, opposed by the Institution of Civil Engineers, as all such proposals are. It seems strange that another application has been postponed so long, but presumably there will be no valid objection this time. Indeed, there seems to be some disposition on the part of the Council to truckle to the Civils, for the proposal is made that members shall be entitled to the exclusive use of the designation "Chartered Electrical Engineer," just as the Civils are now trying to establish a "Chartered Civil Engineer." This word "Chartered" does not seem to convey much distinction; it is too reminiscent of the proverbial "chartered libertine." If we have any grumble to make

against the Electricals, it is that they admit stockbrokers who may happen to be on the board of electrical companies to full membership of their Institution.

ELSEWHERE in this issue we print extracts from Dr. J. D. Falconer's Bulletin on the geology of the tinfields of the Bauchi Plateau in Nigeria. This is No. 1 of a series of bulletins in course of preparation by the Geological Survey of Nigeria, which was established in 1919, with Dr. Falconer as director and Captain R. C. Wilson as assistant director. The scientific staff was augmented in 1920 by the appointment as geologists of Messrs. C. Raeburn, F. Y. Henderson, and A. D. N. Bain. Dr. Falconer, together with Messrs. Raeburn and Henderson, have been chiefly engaged in mapping the tinfields, and Captain Wilson and Mr. Bain in exploring the railway belt. The extracts which we give comprise only a small portion of the bulletin, but they suffice to indicate the general geology of the plateau as now interpreted. Specific references to the rocks and alluvial deposits are omitted, and it has been impossible to reproduce the geological map. We have, however, drawn an outline topographical map, which will help in the reading of the article. As regards the merits of the bulletin, mining engineers will have no two opinions, for it is obvious that the information and the reasoning will be vastly helpful and encouraging to the manager and prospector. Dr. Falconer's book on the Geology and Geography of Northern Nigeria, published in 1911, written as a result of investigations made for the Colonial Office, was useful to the pioneer, though, as the author said, the ground covered was large and there was no great concentration on any particular line of investigation. The man in search of ore, wrongly impatient of geological studies of no immediate financial aid to him, did not appreciate that book in the way he should. However, he ought to be satisfied now, for the bulletin gives him just the information he desires. Dr. Falconer has substantially modified some of his views, after prolonged acquaintance with the tinfield, and after studying the evidence brought to light during the mining operations of the last few years. In this way he has been able to amplify the explanation of the geological history of the district, and to unravel the complicated succession of igneous and volcanic actions and intermediate erosions. Thus, he can give hopes for the discovery of many buried alluvial deposits likely to be rich in tinstone. Several mining engineers have already expressed views to this effect, and it is consequently gratifying to all interested in Nigeria that Dr. Falconer should accept this interpretation of Bauchi geology. As we have already said, it is impossible to quote Dr. Falconer in full in our pages. Engineers should read the complete bulletin in order to understand the matter fully. The bulletin is published by the Nigerian Government, but is obtainable at the Technical Bookshop of THE MINING MAGAZINE, at the price of ten shillings.

THE forty-fourth annual dinner of the old students of the Royal School of Mines was held on May 27 at Gatti's restaurant in the Strand, and, as usual, proved a highly successful function. The toast of the evening was proposed by Sir Edgar Walton, High Commissioner for South Africa. In reply, the President, Professor S. J. Truscott, called attention to the presence at the dinner of many official representatives of the Overseas Dominions, and took the opportunity of pointing out the strong and increasing interest taken by leaders of thought in all parts of the Empire in the scientific treatment of mining problems, and in the provision of modern educational facilities for training the rising generation in a manner adequate for the tackling of the ever-increasing difficult problems with which a mining engineer is faced. Mr. R. C. Griffith subsequently proposed the toast of the Guests, to which Sir James Allen, High Commissioner for New Zealand, and Mr. C. McDermid, Secretary of the Institution of Mining and Metallurgy, responded. Mr. McDermid arrested the attention of his hearers by giving some inside history of the saving of the Royal School of Mines and the creation of the Imperial College of Science and Technology. Let us say that the Council of the Institution collectively and Mr. McDermid individually have taken no small part in overcoming the inertia and indifference of the Government educational authorities and in bringing the Imperial College to a high level of efficiency and influence. While on this subject of the Institution's services to education, we would express the hope that the Council will before long take another step in assisting the educational cause by reinstating the post-graduate scholarships which were suspended

during the war. With mining in such a depressed condition, it may hardly seem to be an appropriate time for reviving this scheme, but it must be said that its abeyance partakes to some extent of the nature of a damper.

REVIEWING Lieutenant Smart's new book on breathing apparatus used in mine rescue work, Mr. Stanley Nettleton draws attention to the records in this book of noxious gases given off by explosives. Lieutenant Smart's experience was partly obtained at the Front, and partly in the mines, and he draws on much of his war experience for the benefit of the mining engineer. Of all the noxious gases mentioned by him, carbon monoxide is by far the most insidious and dangerous. It is deadly, and at the same time undetectable by the five senses. If it had not been lighter than air, it would have been the poison gas par excellence in warfare. And there is no antidote to carbonic-oxide poisoning, for its effect is to change the character of the blood in a vital manner without any hope of a reversal of the process. Lieutenant Smart mentions the opinion of certain authorities that the effect of the presence of this gas in the resultant fumes of explosive action in mines is to induce tuberculosis in the lungs. At the present time quartz spicules are bearing the blame for miners' phthisis, and the effect of poisonous gases is in the background. While writing of the deleterious effects of carbonic oxide, it is appropriate to mention that the towns' supplies of so-called illuminating gas now contains 20% of this poisonous gas. The gas delivered to our homes for lighting, heating, and cooking purposes is the rankest of poisons, and woe be to those who by inadvertence or carelessness permit its escape in unconsumed form. The source of danger is not by any means confined to the want of care on the part of the members of the household, for many stoves supplied by the gas companies are badly made and do not burn all the gas emitted, while there is always the danger of accidental leaks in pipes and fittings, and we are well aware of the deficient intellect of the ordinary plumber. No doubt those who read the reports of the coroner's courts know something of the alarming increase in gas poisoning recently. Reverting again to the quartz spicules, it will be remembered that various authorities have said that the ill effects of these spicules can be obviated by adding other dust to the air breathed into the lungs. At a recent meeting of the American Institute of Mining and Metallurgical Engineers, Dr. H. M. Landis gave evidence which goes to raise doubts on this subject. In speaking of the potter's phthisis, he said that the potter inhales clay dust in which there is a small amount of silica, and that in the course of years the potter's lungs get into the unsatisfactory state associated with silicosis. The conclusion is that silica is always the cause of the trouble, and that admixture with clay and similar harmless minerals tends to postpone the evil day. Thus the addition of other mineral dust to the mine air is only a palliative and not a certain prophylactic.

Central Mining and Investment

In the last issue a brief survey was made of the results of mining on the Rand, and of the present outlook there. Since then the report of the Central Mining and Investment Corporation has been published, containing a review by the Company's consulting engineer, Mr. Hugh F. Marriott, of the performances of the mines under the control of the Central Mining–Rand Mines group. Mr. Marriott's yearly reports are already well known for their directness and clearness of statement, and for their freedom from suppression or meretricious glozing of the less favourable circumstances. In the present report Mr. Marriott makes his primary calculations on the basis of the par value of gold, so that it is possible to see at a glance the influence of the premium on the current fortunes of the mines. He also gives full particulars of working costs, with comparative figures for the previous year. We extract from his report a few of the many interesting points.

The Central Mining–Rand Mines group controls no fewer than twenty mines operating on the Rand. Among these are found mines of all sorts of conditions and age. First in point of importance is New Modderfontein, which shares with Government Areas, of the Barnato group, the honour of being the greatest gold mine of the world. Its neighbour, Modderfontein B, is also a big producer, and another neighbour, Modderfontein East, is typical of the new work now being done in the Far East Rand under the adverse conditions of financial stringency. Crown Mines, City Deep, and Village Deep are celebrated large deep-level properties. Robinson is an ex-greatest gold mine of the world, just about at its

end ; East Rand Proprietary is one of the great low-grade consolidations, and it is struggling for its existence. Ferreira Deep and Wolhuter are old mines approaching exhaustion. Rose Deep, Geldenhuis Deep, Knight Central, Durban Roodepoort Deep, Consolidated Main Reef, and Nourse Deep live by the grace of the gold premium, at the present level of costs. Bantjes has given poor development results, and is closed. City and Suburban, New Heriot, and Village Main Reef are mines with excellent records, but are now entirely exhausted.

The gold output of this group during 1920 was worth £15,879,251, par value, or nearly one half (to be exact 47½%) of the Rand output, which was £33,231,257. The whole output of the world during 1920 was estimated at 70 million pounds, so it will be seen that Central Mining controls 28% of the world's production of gold. The aggregate working expenditure at this group of mines was £14,911,835, so that without the premium the working profit would have been only £967,416. The premium brought an additional revenue of £4,913,764, making the total profit £5,881,180, out of which £4,280,336 was distributed as dividends. The mines showing a working profit, exclusive of premium, were the following :—

	£
New Modderfontein	1,031,185
Modderfontein B	492,984
Crown Mines	209,603
City Deep	173,734
Modderfontein East	24,725
Ferreira Deep	32,287
Rose Deep	8,002
Total	1,972,520

It will be seen from the figures quoted here that the aggregate losses at par value were about one million pounds ; of the individual items, the largest were : East Rand Proprietary, £334,459 ; and Durban Roodepoort Deep, Geldenhuis Deep, Nourse Mines, and Village Deep, approximately £100,000 each.

Mr. Marriott analyses the figures for revenue, costs, and profits per ton milled, and shows that at the mines belonging to the group the average yield at par was 28s. per ton, average additional revenue accruing from premium 8s. 8d., total revenue 36s. 8d., working cost 26s. 9d., working profit at par 1s. 3d., working profit, including premium, 9s. 10d. There is also the item of taxation, over and above working cost, of 1s. 5d. per ton, so that taking gold at par there would have been a net loss of a few pence per ton. Mr. Marriott sees the chance of the cost of materials coming down, but does not hold out much hope for a reduction in white labour costs unless some drastic changes in conditions are introduced, and modifications made in certain obsolete mining regulations, which unduly restrict the hours of work of native labour and prevent the natives undertaking higher classes of work.

The Porphyry Coppers

Some elaborate tables have been published by Messrs. Hayden, Stone & Co., of Boston, giving particulars of the outputs, reserves, profits, and financial positions of the Jackling group of copper mines usually known as the "porphyries", or "disseminated coppers", namely, the Utah Consolidated, Nevada Consolidated, Chino, and Ray. These, with the Miami, Inspiration, and Arizona, constitute a class of copper mine by themselves, which depend for their success on the cheap mining of immense low-grade ore-bodies, in which the important copper mineral is chalcocite. Utah Consolidated has been producing since 1905, Nevada Consolidated since 1907, Ray since 1910, and Chino since 1911. They had a set-back at the outbreak of war, owing to foreign trade being dislocated, but afterwards the big war demand brought unwonted prosperity during 1917 and 1918. Subsequently the output had to be curtailed, and the figures for 1919 and 1920 are about half those of 1917 and 1918, and correspond virtually to those of 1912 or 1913. The costs have gone up during the past two years, and the price of copper has fallen, so that during 1920 the margin of profit became very narrow. Since the end of 1920 the position became worse, and, as already recorded in these columns, operations have been suspended at all the Jackling coppers.

It is quite impossible to reproduce the tables here owing to the exigencies of space. All we can do is to quote some of the items of interest, and recommend readers to apply for copies of the originals. At the Utah Consolidated the ore milled during 1920 was 5,556,800 short tons, averaging 1·16% copper, from which 101,897,758 lb. of metal was extracted, the recovery being 81·38%. At the Nevada Consolidated, 2,568,588 tons, averaging 1·45%, yielded 48,311,895 lb., the recovery being 70·2%. At Chino, 1,838,148 tons, averaging 1·76%, gave 44,051,849 lb., the recovery being 70·67%. At Ray, 1,706,928 tons, averaging 1·72%, gave

47,062,030 lb., the recovery being 82%. The percentage of recovery has improved considerably during the past two years at Utah and Ray, the 81 and 82% comparing with about 65% six years ago. The improvement is due to the introduction of flotation plant, and it is of interest to remark that the validity of the process used is still the subject of litigation. Apparently this system of concentration is not used at Nevada Consolidated or Chino, for the recovery figures do not show much variation. The improvement at Utah has been so substantial that it has been possible to maintain the output of copper, though the ore treated contained only 1·16% metal, as compared with 1·35%, the average of the reserve.

A study of the statistics relating to cost and price of copper per pound indicate the irregular nature of these items in base-metal mining. At Utah Consolidated the cost per pound shows a steady fall from the beginning of operations intil 1915, when the figure was as low as 6·6 cents. Subsequently it rose once more, advancing to 6·95 cents in 1916, 11 cents in 1917, 12·5 cents in 1918, and 13·1 cents in 1920. During the years 1916 and 1917 the prices obtained for the copper were 26·14 cents and 24·18 cents, figures far higher than any other recorded. It is not surprising therefore to find that the disbursements to shareholders for those years were 19½ million and 23½ million dollars respectively. During 1919 and 1920, the average was 17·7 cents in each case, so that the margin of profit was not great. At Nevada Consolidated the cost per pound in 1920 was 17·28 cents and the price realized 17·7 cents; at Chino, 14·4 cents and 17·4 cents; and at Ray, 15·5 cents and 17·5 cents respectively.

The reserves of ore at the four mines are best given in the form of a table :—

	Tons.	%
Utah Consolidated....	364,130,800	1·35
Nevada Consolidated .	63,845,631	1·58
Chino	105,689,247	1·53
Ray	83,004,043	2·06

The reserves are not quite so high at Utah as they were four years ago, the new ore added being about half the amount of ore mined; the same may be said of Nevada Consolidated. For the last five years no new ore appears to have been brought in at Ray; on the other hand, considerable additions have been made to the reserve at Chino.

As a companion table to that dealing with ore reserves, we give herewith figures for the tonnage treated and the copper produced from the beginning of operations at each mine. The dates of commencement have already been given.

	Ore. Tons.	Copper. Short Tons.
Utah Consolidated....	89,340,223	773,076
Nevada Consolidated .	35,180,801	379,840
Chino	21,490,415	255,156
Ray	23,522,127	279,766

The disbursements to shareholders since the beginning, together with the surplus at the end of 1920, are given in the following table :—

	Total Disbursements. $	Surplus at end of 1920. $
Utah Consolidated....	111,509,662	44,177,422
Nevada Consolidated .	46,768,616	6,537,602
Chino	29,991,709	13,889,908
Ray	25,412,620	14,264,228

Messrs. Hayden, Stone & Co.'s circular also contains some general figures relating to the copper position in the United States. The unsold stock of copper in the United States is estimated as at April 15 at 362,500 short tons; the figures given for the output, domestic consumption, and export for 1913, 1918, and 1920 are as follows :—

	Short Tons. 1913.	Short Tons. 1918.	Short Tons. 1920.
Output	810,000	1,177,500	832,500
Domestic Consumption	382,500	740,000	622,500
Exports	437,500	377,500	242,500

These indicate at a glance the inability of foreign customers to buy American copper, and the fact that the United States has been able to consume much more copper in 1920 than in 1913. It would appear that the slump in 1921 has been caused, not so much by any further fall in exports, but by a slackening of domestic demand.

As regards cost of production throughout the United States, the figure for 1920 is given at 15·5 cents per pound, for 1918, 15·47 cents, and for 1913, 10·5 cents. The estimated average prices for the same years were 17·46 cents, 24·63 cents, and 15·27 cents respectively. The price at April 15, 1921, was 12·75 cents, a price below the average cost of production, and one which indicates a serious fall in demand. That so many mines should have closed, and no improvement since have occurred in the price, shows how dead the market is and to what a low level consumption has fallen. The cut in wages in the manufacturing industries in America may revive the demand, but the producers are still looking in vain for an improvement in foreign business.

REVIEW OF MINING

Introduction.—The general situation remains much the same as last month. The coal strike continues, and efforts are still being made to find a way out of the difficulty. In the meantime other industries have been brought to a standstill. In the Lancashire cotton trade the position is almost identical with that in coal mining, the employees objecting to the big cut in wages proposed by the mill-owners. As regards metal mining, the chief item of importance is another sudden drop in New York exchange, the effect of which has been to send the gold premium up again.

Transvaal.—The cost of mining has provided the subject for many addresses by chairmen of mining companies during the last month. Mr. Walter McDermott, in his speech at the meeting of shareholders of the Consolidated Mines Selection, held in London, went bald-headed for the agitators who apparently want the business of the world to come to a standstill. In the case of this company, orders for necessary new machinery cannot be filled in this country, owing to the coal strike and the concomitant paralysis of the steel industry, and, in default of any other resources, the machinery has been obtained from Germany. One of the shareholders expressed a doubt as to the advisability of Mr. McDermott making this attack on labour, but the sense of the meeting was soon seen when another shareholder expostulated in no uncertain words with the first shareholder for his timidity and his disinclination to meet the labour agitators face to face. The result was that Mr. McDermott was thanked by the whole meeting for his courageous stand.

Another speech of importance in this connexion was made by Mr. Samuel Evans, in his capacity as chairman of the Crown Mines, at the meeting held in Johannesburg. He expressed his opinion that prices of materials and labour would fall to such an extent during the next few years that the costs of all operations, including mining, would soon reach a low level. He was sufficiently optimistic to believe that before long it might pay Crown Mines to start from the outcrop of the Main Reef once more and work 3 dwt. ore.

Elsewhere in this issue we quote Mr. H. F. Marriott's analysis of the results for 1920, and his views as to the future of Rand mining contained in his report to the Central Mining and Investment Corporation. We also print in full Sir Lionel Phillips's speech to shareholders of Central Mining.

The crank-shaft of the hoisting engine in the Driefontein section of the East Rand Proprietary Mines broke on June 1. If a suitable shaft can be obtained locally, the period of idleness will not be more than a fortnight.

The report of the Transvaal Consolidated Land and Exploration Co. contains some particulars of the company's tin operations in the Northern Transvaal. The Groenfontein mine made a profit of £13,208 during 1920, but it is now closed temporarily owing to the low price of tin. The Mutue Fides mine is exhausted, after having yielded satisfactory profits on a small scale. At Witfontein the early promise did not endure, and prospecting work has been discontinued. The Welgelegen prospect is giving encouraging results, and so is Allemansdrift.

Cape Province.—A scare was started last month in the daily press to the effect that De Beers Consolidated was about to make a new issue of debentures, and the public consequently feared that the diamond position was unexpectedly serious. When the official announcement was made, the proposed issue was found to be in connexion with the Cape Explosives Works, Ltd., which operates the explosives factory near Cape Town, founded by De Beers, and subsequently becoming famous owing to the distinguished technical management of Mr. W. R. Quinan and Mr. Kenneth Quinan. These works have been considerably extended recently, the funds being advanced by the De Beers Company. The issue of the debentures of the Cape Explosives Works, Ltd., was made for the purpose of repaying De Beers for the loans. It is of interest to note that the extension of the works was in connexion with the manufacture of other articles than explosives. Superphosphate of lime and a number of other fertilizers are now being made, as well as many other chemicals used in agriculture and cattle raising. The debentures were eagerly subscribed by the public.

Work at the Namaqua Company's copper mines continues to be confined to exploration and development owing to the conditions not favouring a resumption of smelting. The results have been gratifying, and the reserves have been substantially increased, particularly at the Homeep property. The

total reserves at the various mines is estimated at 63,200 tons, averaging 7% copper. Of recent years the company used to produce a matte and ship it for treatment elsewhere. Present economic conditions would not admit of this course, so the directors contemplate the erection of a converter plant.

West Africa.—In a recent issue it was recorded that the Ashanti Goldfields Corporation is changing over from dry to wet crushing, on account of the great scarcity of fuel required for roasting the ore, the new plan consisting of wet crushing, concentration, and the roasting and cyaniding of concentrate. A report issued by the company last month states that Mr. W. R. Feldtmann, the consulting engineer, has visited the mines, and has made the necessary arrangements for the alteration in practice. The new plant is now in course of erection. In regard to the fuel question, the company was fortunate in being able to secure 2,000 tons of Welsh steam coal and ship it just before the strike. It is believed that this coal will so supplement the present local wood supplies as to keep things going until the wet crushing and concentration plant is ready.

Nigeria.—The Keffi Consolidated Tin Co. is to absorb the Associated Nigerian Tin Mines. These two consolidations were formed last year and in 1919 respectively, and particulars were given in this column at the time. The expanded company owns extensive properties on the Bauchi Plateau. The directors intimate that they are concerned in the financing of a hydro-electric power scheme. We take this to mean that they are coming to the rescue of the Northern Nigeria (Bauchi) installation, the completion of which was prevented by inability to raise the necessary additional capital.

The Naraguta (Nigeria) Tin Mines, Ltd., has issued a circular containing a report by the general manager, Mr. F. O'D. Bourke, covering a report by Mr. Clyde Allan, which gives some particulars of prospecting and development operations on the gold lodes of Birnin Gwari. It was assumed by the market that this report referred to absolutely new discoveries. As a matter of fact, the occurrences have been known for many years. Dr. Falconer, in his book published in 1911, refers to quartz veins and alluvial gold in this district, and he gives many suggestions as to opportunities for prospecting for gold-bearing lodes. He also refers to alluvial gold being found in association with tin on the Bauchi Plateau, a subject which has been revived in the mining market since the Naraguta circular was issued. Mr. Clyde Allan's report deals with the tracing of lodes below the alluvium, and some of his results may be considered to be quite promising.

The report of the Nigerian Tin Corporation for the 21 months ended December 31 last reflects the unsatisfactory position of the tin industry in Nigeria. The company is not a large producer of tin, its activities being more on the financial side. The output yielded £13,885, against an expenditure in Nigeria of £19,338. Tin mining has since been suspended. Dividends, commission, interest, and profits on realization of investments brought an income of £15,153, and after the payment of London expenses, a net profit of £4,617 remained. The company is controlled by Mr. Oliver Wethered, and it has large interests in many Nigerian, Cornish, and Malayan tin companies.

Australia.—The attempts of various companies to induce their men to accept lower wages and speed up the work all appear to be doomed to failure. The men may be agreeable, knowing the circumstances, but all their negotiations have to be conducted by the unions, who care little for either master or men. Thus at Mount Lyell the board's proposals for reduced wages have been rejected, so that all operations are to be suspended on June 16.

The directors of the Bullfinch Proprietary have placed the management of the mine in the hands of Bewick, Moreing & Co., who will inaugurate a limited scheme of development for the purpose of finding payable ore.

A report by Mr. J. B. Lewis has been issued on the Federation Tin Company's properties at Mount Heemskirk, on the west side of Tasmania. As there is a movement on foot for raising further working capital in England, some particulars of the property will be of interest. The granite is intersected by many lodes of varying mineralogical composition, all characteristic of the usual intrusions of residual matter following the granite flow. Twenty lodes from 2 ft. to 30 ft. in width have been sampled, and have been proved to contain ½% and upwards of tin. Sufficient work has been done on eight of the lodes to warrant an estimate of the reserves. Mr. Lewis gives the figure at 57,700 tons, averaging over 1%, with the probable ore at 450,000 tons. The district was originally discovered in 1875, and work

was done intermittently in 1880, 1893, and 1903, but owing to the small scale of operations the financial results were not satisfactory. There is now a battery of forty stamps on the spot. A dam has been built across the valley, and a hydro-electric station is to be erected. It is believed that under these conditions excellent profits will be made when tin recovers.

India.—The Gersoppa falls, in Mysore State, are to be utilized for the production of hydro-electric power, the Government of the State having the matter in hand. The falls are 830 ft. high, and the power-house is to be 150 ft. below the bottom, so that a head of over 1,000 ft. will be obtained. A dam is to be built above the falls. This will be 120 ft. high, and the reservoir so formed will have a capacity of 42,000,000,000 gallons. It is estimated that 100,000 h.p. will be generated.

Burma.—The Burmah Oil Company is about to issue £3,000,000 8% preference shares, which are part of £5,000,000 new preference shares authorized at a meeting held in Glasgow on June 1. The directors also proposed that the two existing series of preference shares should be consolidated, and the rate of interest raised to 6½%, but the votes in favour did not give the necessary three-quarters majority. Why so many shareholders failed to send their proxies is not quite clear.

Malaya.—The Idris Hydraulic Tin Company reports a yield of 263 tons of tin concentrate during 1920. This and tributers' ore brought an income of £46,979, and the profit admitted of the payment of £18,000 as dividend, being at the rate of 15%. As is the case with most other Malay tin mines, little or no curtailment of output has been made since the serious fall occurred in the price of the metal.

Cornwall.—A serious accident at East Pool occurred last month, resulting in the choking of the main hoisting shaft at about the 130 fathom level. At this point the shaft runs through an old stope, and it was the collapse of this stope that caused the blockage. It is too early to estimate the actual amount of damage done.

The only Cornish tin mines which have so far weathered the gale of adverse circumstances and kept running are the Giew mine of the St. Ives Consolidated Mines, and the small privately owned Magdalen mine at Ponsanooth. As neither of these can boast of anything remarkable in the way of mineral riches, their continuance in active operation is surprising, and creditable to those in control.

At the Kingsdown mine, near St. Austell, the new main shaft has been sunk and timbered to 220 ft., and the erection of the pumping and hoisting plant is in hand. Development below water level will be commenced forthwith. The lease of the adjoining Ventonwyn property has been secured.

Particulars of Cornish Kaolin, Ltd., have been published during the past month. As has already been mentioned in these columns, the company was formed in 1912 to work china-clay deposits on Bodmin Moor, on lease from Lord Clifden's estate. This estate now belongs to Tehidy Minerals, Ltd., and the mineral rights were acquired by the company when the control was purchased recently from the original operators. Messrs. Bewick, Moreing & Co. are the general managers, and the necessary working capital has been subscribed by the Sons of Gwalia, Ltd., East Pool & Agar, Ltd., and Tehidy Minerals, Ltd. The previous operators had developed the Glynn Valley property, and had built a pipe-line to Bodmin Road Station, where a dry was erected. Since the change in control, further deposits of clay have been proved, and arrangements have been made for increasing the rate of output.

United States.—Further curtailment of copper output has taken place, among the mines closing recently being the Copper Queen and the mines of the Arizona Copper Company.

The Anaconda Copper Mining Co. mined 2,152,760 tons of ore during 1920, a figure considerably below normal, but an increased amount of exploratory and development work was done, with very satisfactory results. At the copper smelters 2,319,336 tons of ore and precipitate was treated, of which 1,828,379 tons came from the company's mines, 458,339 tons was purchased or custom ore, and the remainder precipitate and cleanings. The total copper produced was 155,339,575 lb., the silver 7,113,659 oz., and the gold 32,530 oz. The leaching plant treated 484,352 tons of tailing and 43,271 tons of purchased ore, and the yield of copper precipitate was 5,037 tons. The zinc plants treated 310,572 tons of the company's ore and 133,010 tons of purchased material. The yield was 101,332 lb. of electrolytic zinc, together with

5,255,152 lb. of zinc in dross, and residue from which were produced 12,536,088 lb. of lead, 2,173,080 lb. of copper, 2,073,348 oz. of silver, and 6,150 oz. of gold. The net profit for the year was $2,691,660, and the dividends, partly paid out of surplus, absorbed $6,993,750.

Canada.—The following table gives the output of metals and minerals in Canada during 1920:—

Metallic.		
Cobalt, metallic and contained in oxide, etc.	Lb.	593,920
Copper	Lb.	81,155,360
Gold	Oz.	766,912
Iron, pig, from Canadian ore	Tons	75,869
Iron ore, sold for export	Tons	7,855
Lead	Lb.	33,985,974
Nickel	Lb.	61,136,493
Platinum from alluvial sands	Oz.	17
Platinum, palladium, etc., from Sudbury matte	Oz.	1,922
Silver	Oz.	12,793,541
Zinc	Lb.	40,166,200
Non-Metallic.		
Actinolite	Tons	100
Arsenic, White, and in Ore	Tons	2,408
Asbestos	Tons	167,731
Asbestic	Tons	20,956
Chromite	Tons	10,500
Coal	Tons	16,623,598
Felspar	Tons	36,856
Fluor-spar	Tons	11,229
Graphite	Tons	2,227
Grindstones	Tons	2,319
Gypsum	Tons	429,144
Magnesite	Tons	18,373
Magnesium Sulphate	Tons	1,855
Mica	Tons	2,150
Natural Gas	M. Cu. Ft.	16,961,284
Oxides	Tons	18,768
Peat	Tons	3,900
Petroleum, Crude	Barrels	196,937
Pyrites	Tons	174,744
Quartz	Tons	127,995
Salt	Tons	210,211
Sodium Sulphate	Tons	813
Tripolite	Tons	260

Dr. Mackintosh Bell, manager of the Keeley silver mines, situated near Cobalt, cables to the effect that on No. 9 vein the ore averages 150 oz. silver per ton over 3 ft. for a distance of 65 ft. Toward the end of this development the silver is contained in two separate veins which average 300 to 3,000 oz. per ton over 2 to 10 in. This is the best report yet received from the mine.

Mexico.—The official estimate of the output of gold and silver during 1920 gives the gold figure at 750,000 oz. and that of silver at 63,750,000 oz.

Colombia.—During the latter half of 1920 the Frontino and Bolivia company treated 15,320 tons of ore, yielding 10,665 oz. of gold, the extraction being 13·92 dwt. per ton. The development has given disappointing results at several places and the reserves, at 58,200 tons, show a decrease of 7,500 tons. At the Marmajito, which is being reopened by a subsidiary company, the pumps and other machinery have been delivered, and it is expected that pumping will commence in July.

Trinidad.—The General Petroleum Company of Trinidad, Ltd., is absorbing the Amalgamated Oilfields of Trinidad, Ltd., the Anglo-Trinidad Oil Co., Ltd., and the San Francique Oil Co., Ltd. These companies are all under the same control. Sir Clifford Cory and Mr. Herbert Guedalla are joining the board of the expanded company, and Messrs. Cory Brothers and Co., Ltd., the South Wales shipping and coal firm, have the contract for the marketing of the oil. The drilling campaign was started recently, and the first well yielded oil on May 12, at a depth of 900 ft., the flow being over 150 barrels per day.

Venezuela.—The British Controlled Oilfields, of which Mr. D. Elliott Alves is president, and Sir E. Mackay Edgar vice-president, has issued an interim report. In the western division of the Buchivacoa section drilling is being done over 40 miles, six wells having been drilled or being in course of drilling. One of these has been flowing intermittently for fifteen months. No. 2 well has reached the upper oil sands at 630 ft. In the eastern division two wells are being drilled and another is to be commenced. No very definite results appear to have been obtained so far in any part of Venezuela by the company's engineers. Rights over a number of islands in the Orinoco delta have been acquired, and Mr. G. B. Reynolds has examined part of the property, indicating suitable places for drilling. Brief particulars are also given of work in Trinidad and Ecuador. Geological examinations are being made in Colombia and Costa Rica. The company also has concessions in other parts of Central America, where Mr. B. F. N. Macrorie is to make investigations.

Spitsbergen.—The Scottish Spitsbergen Syndicate announces that arrangements are in hand for forming a subsidiary company to develop its proved coalfields in the Klaas Billen Bay area. It has been decided to continue the investigation of other coal-bearing districts, and for this object a small expedition has been sent to the islands this spring.

NIGERIAN GEOLOGY

A STUDY OF THE ROCKS AND SURFACE DEPOSITS IN THE CENTRAL TIN-PRODUCING DISTRICT OF THE BAUCHI PLATEAU

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We present herewith, by permission, a brief résumé of Bulletin No. 1 of the Geological Survey of Nigeria.

Introduction.—The area over which the tinstone is distributed in Northern Nigeria lies at an average elevation of 2,000 ft. above the sea. It includes, however, the plateau of western Bauchi, which rises to an elevation of over 4,000 ft., is bounded on the north, west, and south by a more or less dissected escarpment, but on the east slopes gently downward to the plains of the Gongila. The richest deposits of tinstone have so far been found on and around the Bauchi plateau, and the tinfields as a whole may be subdivided into three sections :

(1) The Plateau Tinfields of Bauchi Province.

(2) The Northern Tinfields of Bauchi, Kano, and Zaria Provinces.

(3) The South Western Tinfields of Nassarawa Province.

The present Bulletin deals with an area of about 1,800 square miles, extending from the Delime valley in the north to the margin of the closed country in the south, and including the northern front of the plateau and the whole of that portion of the plateau over which tinstone is now being won. No account is given of the extreme southern portion of the plateau, which is also tin-bearing, but which is at present closed to prospectors for political reasons.

General Geology.—An ancient crustal complex of gneisses, schists, and gneissose granites has been invaded by a younger granite batholith, the higher portions fo which have been, in course of denudation, exposed at the surface and now appear as a series of detached stocks, bosses, and dyke-like masses separated from each other by more or less extensive areas of older rocks. Upon the plateau itself seven main outcrops of younger granite have been recognized. These may be termed : (1) Bukuru-Shere ; (2) Rukuba-Buji ; (3) Vom-Ganawari ; (4) Jarawa-Fusa ; (5) Forum ; (6) Ropp-Dress ; (7) Sha. The Bukuru-Shere and Jarawa-Fusa outcrops are connected at the surface by a number of narrow necks or bars of granite porphyry. Otherwise the various outcrops are entirely separated from each other.

The younger or "plateau granite" is typically a medium-grained biotite granite, pink, red, white, or yellow in colour from the prevailing tint of the felspars. It varies somewhat in texture, becoming in places finer grained or coarser grained than normal. It varies also in the amount of biotite it contains, while in some places riebeckite or soda hornblende replaces biotite. Marginally the granite tends to pass into a granite porphyry with felspar and quartz crystals set in a matrix of fine-grained granite rich in biotite. At its junction with the older rocks the granite usually becomes fine grained and microgranitic, occasionally micrographic or felsitic, with scattered porphyritic crystals and knots of quartz and pegmatite.

Associated with the granites and marking one of the later stages of igneous activity is a series of basic and acid dyke rocks. The basic types are mainly fine-grained basalts and dolerites, which, while most abundant outside of and on the margins of the granites, are also found in the interiors of the outcrops. The acid types include many varieties of felsite and quartz-porphyry.

After consolidation the younger granite was much broken and fissured. Along some of the fissure lines movement took place and gave rise to definite crush structures. More generally, however, the fissures formed lines of egress for vapours and solutions from the igneous focus, with the result that in places the granite suffered considerable alteration and mineralization along and in the neighbourhood of the fissure lines. The alteration was mainly in the direction of greisenization and silicification with addition of topaz and tinstone.

The older rocks which the younger granite invaded are of many and varied types. There would appear to have been originally occupying the site of the plateau a series of metamorphic rocks of mixed sedimentary and igneous origin into which two types of gneissose granite were injected. No mineralization accompanied these earlier intrusions, and no metamorphism of the older rocks took place as the result of the

injection into them of the younger granite. In places, however, the older rocks were altered by pneumatolytic action in the same way as the younger granite.

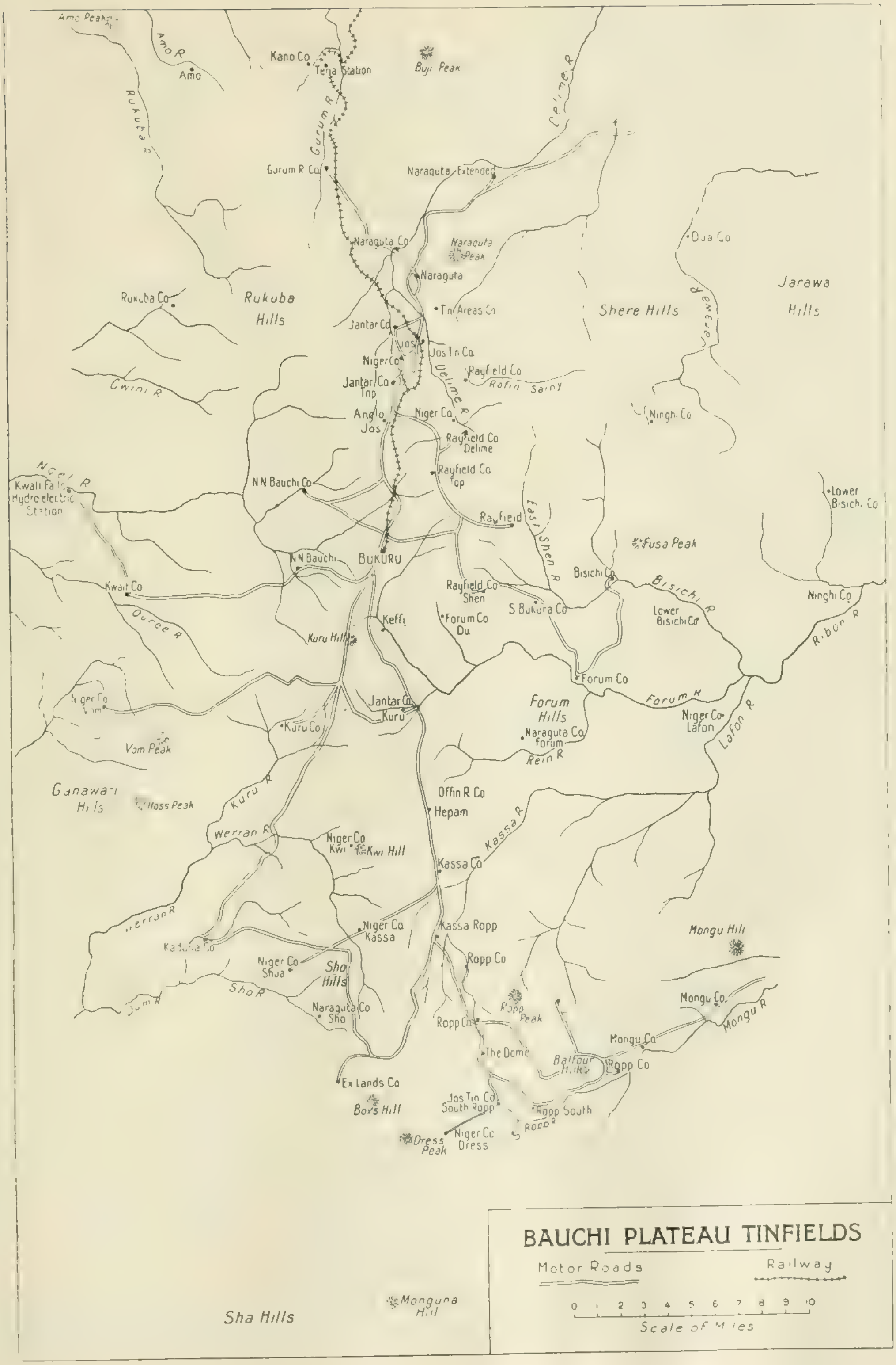
After the close of igneous activity long ages of denudation supervened, during which the older rocks were attacked and worn away and the upper surface of the younger granite batholith gradually exposed. The covering of older rocks has not yet been entirely removed, with the result that considerable stretches of the older series still separate the various granite outcrops, while in places detached masses of older rock can be seen still adhering to the surface of the granite. The upper surface of the batholith was probably highly irregular and the major irregularities on the surface of the plateau probably represent much reduced fangs of the younger granite which originally projected upward from the general surface of the batholith into the overlying rocks.

Where the covering of older rocks has been completely removed, a considerable portion of the superficial layer of the granite outcrops has also disappeared. It is believed that this upper layer of granite and, doubtless, also the older rocks immediately overlying were in places highly mineralized, indication of such mineralization being still apparent in the granites. In the course of denudation, and before the elevation of the plateau, the tinstone from the mineralized areas became gradually concentrated in stream channels on and around the granite outcrops, and possibly as the result of crustal warping and consequent drainage changes, became buried beneath a series of alluvial, eluvial, and volcanic accumulation, for which the name of Fluvio-Volcanic Series is suggested, as descriptive of their most typical development. With the elevation of the plateau, probably in Mio-Pliocene times, the whole surface was subjected to renewed erosion. New drainage lines were established on the plateau and the older superficial deposits in great part removed, while their tinstone content was rearranged along the floors of the present valleys. There still remain, however, considerable areas of the older Fluvio-Volcanic Series, mainly along certain primary and secondary watersheds, forming narrow stretches of high plateau or picturesque groups of flat-topped hills.

At some time during the recent period of erosion volcanic activity again broke out, with the result that large areas of the plateau were flooded with basaltic lava, which not only filled the valleys and covered up the tin-bearing deposits on their floors, but doubtless also obscured many partially eroded portions of the earlier Fluvio-Volcanic Series.

Origin of the Tinstone.—Throughout the areas surveyed, tinstone has nowhere been found disseminated through the plateau granite as a primary constituent. That it may occur locally as such is, however, probable from the fact that at Forum River tinstone occurs in the quartz knots of a marginal granophyre. This implies that small quantities of tin were present in the original magma, and that during the consolidation of the outer layer it was segregated along with the residual silica into miarolitic or crystallization cavities in the marginal granite. Incomplete segregation would result in the dissemination of small crystals of tinstone through the granite. A similar process may have been operative during the consolidation of the interior of the batholith.

So far as can be judged, however, from the area surveyed, this would appear to have been only a minor source of the tinstone of the plateau tinfields. There is little doubt that the greater part of the tinstone is of pneumatolytic origin, and was originally contained in lodes and veins and in mineralized streaks and patches in the outer shell of the batholith and in the older rocks immediately overlying. There is some evidence for the assumption that a highly mineralized belt 4 or 5 miles in width formerly extended from north to south across the Bukuru-Shere massif from the neighbourhood of Jos to the vicinity of Kuru. Throughout this belt there are abundant quartz leaders and veins, and streaks and patches of altered granite frequently carrying tinstone. Loose sub-angular fragments of lode tin of considerable size and weight are frequently found in the surface wash, while the richest alluvial deposits of the Bukuru-Shere massif occur on either side of this belt, which appears to have shed tinstone both to the east and to the west. Throughout the belt alteration and mineralization appear to have followed indifferently joints, fissures, and other lines of weakness running north and south, east and west, and in intermediate directions. A somewhat similar, but less extensive mineralized belt runs north and south through the Ropp massif in the neighbourhood of the Dome. Veins and stringers of cassiterite quartz occur in the older rocks


BAUCHI PLATEAU TINFIELDS
Motor Roads
Railway
0 1 2 3 4 5 6 7 8 9 10
Scale of Miles
Amo R
Amo
Kano Co
Teria Station
Buji Peak
Delime R
Rukuba R
Gurum R
Gurum R Co
Naraguta Extended
Naraguta Co
Naraguta Peak
Naraguta
Dua Co
Jarawa Hills
Rukuba Co
Rukuba Hills
Tin Areas Co
Shere Hills
Jantar Co
Jos
Jos Tin Co
Niger Co
Rayfield Co
Rafin Sainy
Gwini R
Jantar Co Top
Anglo Jos
Niger Co
Delime R
Ningh. Co
Rayfield Co Delime
Rayfield Co Top
NN Bauchi Co
Kwali Falls Hydro-electric Station
Rayfield
East Shen R
Lower Bisich. Co
Fusa Peak
N N Bauchi
BUKURU
Bisichi Co
Bisichi R
Kwall Co
Rayfield Co Shen
S Bukura Co
Ninghi Co
Lower Bisichi Co
R. Ibor R
Keffi
Forum Co Du
Kuru Hill
Forum Co
Forum R
Niger Co Vom
Jantar Co Kuru
Forum Hills
Niger Co Lafon
Lafon R
Kuru Co
Naraguta Co Forum
Rein R
Vom Peak
Ganawari Hills
Hoss Peak
Kuru R
Offin R Co
Hepam
Kassa R
Werran R
Niger Co Kwi
Kwi Hill
Kassa Co
Werran R
Niger Co Kassa
Kassa Ropp
Mongu Hill
Niger Co Shua
Sho Hills
Ropp Co
Sho R
Mongu Co
Mongu R
Naraguta Co Sho
Ropp Peak
Ropp Co
Mongu Co
The Dome
Balfour Hills
Ropp Co
Ex Lands Co
Jos Tin Co South Ropp
Ropp South
Bors Hill
Ropp R
Dress Peak
Niger Co Dress
Sha Hills
Monguna Hill

most frequently in the neighbourhood of the granite margins but sometimes at a considerable distance from them. On the hypothesis that the younger granite may everywhere underlie the older series, where only the latter appears at the surface, there is every probability that the gneisses and schists may in places be highly mineralized. The attempts which have hitherto been made to open up known occurrences of tinstone in the granites and gneisses have proved unsuccessful, but careful prospecting may yet reveal workable lodes, pipes, or stockworks within the rocks of the plateau.

The minerals which have been found in place in existing veins and altered rock include, besides tinstone, topaz and specularite, which are widely distributed, wolframite around Bukuru, near the Dome in the Ropp group, and on the Gwini River in Rukuba, pyrite and chalcopyrite near Jos, galena near Jos and at South Ropp, arsenopyrite on the Jarawa River, and molybdenite near Jos and in the Jarawa Hills. Fluor-spar occurs very sparingly in two localities near Jos, but it is an almost constant accessory mineral of the granite in microscopic crystals. The large crystals of tinstone and topaz with one perfect termination, which are frequently found in the surface wash, have probably been disintegrated from vughs in veins and lodes which have now been removed by denudation. Topaz and mica are the only minerals which have been formed by pneumatolytic action. The complete absence of tourmaline from the younger granite and its pneumatolytic products points to a general deficiency of boron in the original magma, its place having been taken by fluorine, which gave origin to the fluo-silicate, topaz, in place of the boro-silicate, tourmaline. Tourmaline pegmatites, however, are commonly associated with the older rocks, but on the plateau they have not yet been found to be stanniferous.

Fluvio-Volcanic Series.—From the date of the granite intrusion to late Tertiary times there is no evidence of recrudescence of activity in the igneous focus. As the result, however, of long ages of denudation, the cover of older rocks was largely removed and the underlying granite partially exposed. The earlier stages in this process of denudation can no longer be traced. It is probable that there were in the past repeated oscillations of the crustal surface, repeated variations in the rapidity of denudation, and many alternations of periods of erosion and periods of accumulation. During the periods of erosion the tinstone disintegrated from the granites and gneisses was accumulated in the river beds and stream channels, while during the periods of accumulation the valleys were infilled with gritty and earthy wash to such an extent that on the renewal of erosion the rivers frequently formed for themselves new channels over the surface of the land. Owing to the recent elevation of the plateau the present is naturally a period of erosion, but traces of one of the more recent periods of accumulation still remain in the Fluvio-Volcanic Series of the plateau.

It is presumed that during the period of crustal instability which preceded the elevation of the plateau, the transporting power of the rivers was reduced, probably through surface warping, and conditions became favourable for the accumulation of detritus over the site of the plateau. The ancient valleys with tinstone along the stream lines were infilled with river and rain-wash and volcanic material, and the minor irregularities of the surface obliterated by a mantle of debris (the Fluvio-Volcanic Series), which may have reached in places a thickness of 200 ft.

The constitution of the mantle is very variable. Its predominant constituent is a red gritty earth, varying much in the proportions of angular quartz and earthy material. It may be white, yellow, purple, or brown in colour, and streaked, banded, or mottled according to the amount and distribution of the iron oxide. As a rule the colouring becomes more intense towards the summit of the series. Concretionary knots and bands and lenticles of clay ironstone are common, and the more gritty bands are often compacted with a ferruginous cement. These gritty earths probably represent decomposed granitic and gneissic wash, possibly mixed with some volcanic material; their content in iron being due in part to the decomposition of ferruginous and ferro-magnesian minerals originally enclosed in the wash, and in part to the precipitation of iron oxide from ferruginous solutions circulating at a later date through the wash under conditions somewhat different from those existing during the period of accumulation.

Associated with these gritty earths are beds of fine grained, compact, kaolin clays, white, pink, or lilac in colour, breaking with a conchoidal fracture, and containing

occasional knots of quartz. These probably represent original accumulations of felspathic mud in pools of standing water in areas of uncertain drainage.

Also associated with these gritty earths are beds of soft yellow, blue, red, purple, or mottled earths of a peculiar fariniform texture, homogeneous throughout, entirely free from quartz, breaking with an even fracture and occasionally showing traces of a spheroidal structure. Sometimes, as in Kwi Hill they present a vesicular character with the vesicles arranged irregularly or in parallel series. Microscopic investigation has shown that these represent thin beds of entirely decomposed basaltic or doleritic lava, which flowed over water-logged plains during the period of uncertain drainage, and were covered up by further accumulations of rain and stream wash and rapidly decomposed. The alkalis, lime, magnesia, and iron appear to have been largely leached out of these earlier basalts, leaving pseudomorphs of felspar in amorphous hydrated silicate of alumina. Small quantities of gibbsite or hydrated oxide of alumina are occasionally present, especially in the vesicles, and Dr. Morrow Campbell has figured a decomposed dolerite from Monguna, in which the replacing material is mainly gibbsite.

With the basaltic earths are associated reddish earths of similar texture, but showing traces of a brecciated structure and containing a small amount of angular quartz. These are probably beds of much decomposed volcanic ash, the quartz having been an original constituent torn from the walls of the volcanic pipes. The foci from which this material and the associated lavas were emitted are naturally difficult to locate, but it is possible that some of the isolated pipes or plugs of basalt which are found throughout the western gneissic area may represent these older vents.

In this connexion it is interesting to note the occurrence and contents of what appears to have been an ancient volcanic pipe, discovered in the course of drilling operations on the Lower Gona. All traces of the pipe and of its accompanying volcanic accumulation have been removed from the surface, which is now covered to a depth of 90 to 130 ft. with recent alluvial deposits. In the pipe itself the uppermost 320 ft. consist of the usual sands and clays, but from 320 to 350 ft., the limit of the bore-hole, the pipe is filled with fragments of both vesicular and compact basaltic lava in a matrix of basaltic debris mingled with angular quartz grains and fragments of granite and gneiss. If material of this kind had been originally spread out on the surface and then weathered and decomposed, the result would have been a gritty brecciated earth very similar to that described above.

This mantle of gritty earths, clays, and volcanic material would naturally cover up the earlier stream-beds with their accumulations of tin-bearing wash, as well as the earlier detrital deposits on the slopes of the buried valleys. The general aspect of the country at the close of the period of accumulation would be very similar to that of the plains of Zaria at the present day, with occasional knobs, hummocks, kopjes, and groups of hills projecting from the general level, while the solid rocks below their mantle of water-logged debris would themselves be decomposed and whitened or kaolinized to irregular depths. On the higher portions of the surface, and wherever free oxygen could penetrate, iron oxide would be precipitated above the ground water level.

There followed the elevation of the plateau and the consequent renewal of erosion. New drainage lines were established and the mantle of debris rapidly removed from large areas of the underlying irregular surface. Remnants of the Fluvio-Volcanic Series now occur mainly along primary and secondary watersheds as narrow scarped plateaus or rows and groups of flat-topped and pyramidal hills.

One result of the elevation of the plateau and of the renewal of erosion was the freer circulation of the oxygenated waters through the earthy mantle and the consequent abundant precipitation of iron oxide as the level of the ground water gradually fell. With this is to be correlated the deeper staining and the greater content in iron of the upper portion of those relics of the Fluvio-Volcanic Series which still survive. The caps of lateritic ironstone, which are characteristic of the residual hills, and which have been largely instrumental in their preservation, represent certain portions of the original surface of elevation or of a later degradation level which were marked by the excessive deposition of iron in the subsoil. To this result many causes may have contributed, such as the local enrichment in iron of the ground water, the influence of bacteria in the soil, and of capillarity and

evaporation during the dry season, as well as the local issue of ferruginous springs on gentle slopes and valley floors. To the last is probably due the formation of the laminated clay ironstone, which sometimes occurs on the summits of the hills, and in which impressions of leaves are occasionally found. Often the ferruginous cap is simply brecciated ironstone, composed of the re-cemented detritus of some earlier ferruginous deposit which formerly existed in the vicinity. Those ironstone caps which exhibit a porous vesicular, and sometimes pisolitic habit are the enriched and hardened detrital surfaces of the red and white mottled grits and volcanic earths which so frequently

KWI HILL: A RELIC OF THE FLUVIO-VOLCANIC SERIES ON A BASEMENT OF OLDER GRANITE.

form the subsoil. The original mottling is due in part to the irregular deposition of iron, in part to the reducing action of decaying rootlets in the subsoil. On exposure the uncemented material is washed out, and the iron rearranged and compacted by local solution and redeposition and enriched by further capillary activity to form the characteristic scoriaceous cap. Where the deposition of iron is accompanied by that of alumina, the resulting cap may approach a true secondary laterite in composition.

The main economic interest of the Fluvio-Volcanic Series lies in the fact that the component grits, earths, and clays have covered up an old land surface, and with it the alluvial and the detrital tin-bearing deposits which had formerly accumulated along the river lines and on the valley slopes. It follows that underneath the existing remnants of the Fluvio-Volcanic Series there may occur buried river channels or detrital deposits rich in ore. As an example may be cited the occurrence of tin-bearing wash in Kwi Hill, a flat-topped pyramidal hill situated to the south of Kuru. The hill is composed of a thick (100 ft.) bed of volcanic earth or clay, representing a decomposed basaltic lava, set on a basement of gneissose granite with large parallel porphyritic felspars. The clay is white, yellow, or purple in colour, often striated at various angles, becoming vesicular towards the top, and covered with

HEAD OF A RECENT TRIBUTARY CREEK OF THE WERRAM RIVER, WITH A RELIC OF THE FLUVIO-VOLCANIC SERIES ON THE WATERSHED IN THE BACKGROUND.

a gritty ferruginous cap, underneath which the clay is veined, streaked, and knotted with iron ore. Beneath the volcanic earth is a gritty kaolin clay, which on the northern front overlies a deposit of tin-bearing wash much cemented with iron. This deposit had an extension of about 80 ft. into the hill, beyond which it became unpayable.

The Fluvio-Volcanic Series is thus worthy of careful prospecting for buried alluvial and detrital deposits. Its remnants can frequently be recognized as flat-topped hills or narrow plateaus, provided with caps of gritty lateritic ironstone. Where, however, the removal of the Series has been almost completed, relics of the same may be found

on secondary watersheds where no flat-topped hills occur to mark the spot. In their place may be simply rounded ridges or gentle slopes on which the base of the Fluvio-Volcanic Series is represented by a thin cover of sandy wash and broken ironstone.

Recent Volcanic Rocks.—During the period of erosion which followed the elevation of the plateau the ancient surface was largely destroyed and the present topography gradually evolved. The drainage system was rearranged, the present river valleys developed, and the tinstone content of the earlier superficial accumulations reconcentrated along the existing stream lines. This period of erosion was not, however, entirely continuous, one of the most important interruptions being caused by the renewed outbreak of volcanic activity on the surface of the plateau, with the result that large areas were flooded with basaltic lava. The lava not only covered up considerable tracts of country, from which the Fluvio-Volcanic Series had been entirely removed, diverting the rivers and streams from their established channels and burying the recent irregular surface of erosion, but it also mantled considerable areas from which the Fluvio-Volcanic Series had been only partially removed, with the result that it is now found in places wrapping round the bases of residual flat-topped and rounded hills, and in others capping the relic plateaus and adhering to the scarped slopes over which it flowed. It follows that underneath the recent basalts there are buried river valleys and stream channels of varying age, doubtless in some cases carrying rich deposits of tin-bearing wash.

Many foci, large and small, appear to have existed on the plateau, the smaller ones being of the nature of plugs from which little or no lava was emitted. The flows are always without porphyritic crystals of augite and olivine. Of the larger foci in the southern section of the areas mapped, one forms a prominent elevation on the principal watershed of the plateau to the south of the Ropp Hills. The lava of the focus is in places very vesicular and encloses numerous fragments of granite and gneiss. The adjoining flow has not only covered up and protected a considerable area of the Fluvio-Volcanic Series on the watershed, but has also descended over the northern escarpment into the valley of the South Ropp River.

Columnar Basalt in the Dum River.

Another important foci is that of Kassa on the Ropp road, about half-way between Bukuru and Ropp. The focus itself consists of a small group of rounded hills, but the lava from it flooded the whole country between the Kassa River and Kwi Hill, and sent a long tongue eastward towards Lafon, and another westward into the valley of the Kuru River, where, owing to recent erosion, only scattered patches of basalt now remain.

The economic interest of the recent volcanic series lies in the fact that the lavas have covered up an ancient land surface with its river valleys and stream channels, and its remnants of earlier superficial accumulations, all of which may at times carry ancient leads of tin-bearing wash. Prospecting for such deposits is, however, naturally costly and difficult, and little progress can yet be recorded.

ALLUVIAL DEPOSITS.—The progressive degradation of the surface consequent upon the elevation of the plateau can be clearly traced in the varied alluvial deposits of the existing valleys in those regions where recent volcanic accumulations are absent. During the early stages in the dissection of the plateau edge many creeks and gorges must have existed, from which, for various reasons, the streams were diverted at a later date.

Where quartz leaders or mineralized rock-carrying tinstone outcrop at the surface, sharp angular tinstone is found everywhere in the surface wash. On the other hand, when through the progress of denudation ancient terraces have been entirely removed from the slopes of a valley or when older alluvial deposits on watersheds have again come within the cycle of erosion, the surface wash of the valley slopes may carry rounded tinstone in greater or less abundance. On the northern front of the plateau well worn particles of tinstone may be found on bare disintegrating granite surfaces, and in the angular wash at their base. With the tinstone are associated occasional water-worn pebbles of topaz and white quartz, all of which are relics of ancient alluvial deposits.

With the exception of the sharp angular tinstone, which is still being shed from local sources at the present day, the greater part of the tinstone of the plateau tinfields would appear to have been detached and disintegrated from the original veins and lodes and mineralized streaks in the granite and the older rocks at a very early period and to have had a long and complicated alluvial history, of which only some of the latest stages can be traced to-day. In the oldest recognizable deposits of the Fluvio-Volcanic Series, which are generally also the highest, the tinstone is already well rolled and water-worn, and there can be little doubt that these ancient high-level deposits have been the proximate source of the greater part of the tinstone now distributed throughout the lower alluvial accumulations.

The bulk of the tinstone of the plateau tinfields is black in colour, but ruby and grey tin are both common, the latter being sometimes almost white. Small quantities of wood tin are found in places. A semi-translucent resin tin occurs at Forum River, and a somewhat similar variety at Rafin Sainyi on the Ngel River. Black tinstone with a black streak, and in small particles attracted by the electromagnet, occurs near Amo. When in well-formed crystals the tinstone occurs mainly in short square prismatic forms, frequently showing the characteristic twinning. No pseudomorphs in tinstone after felspar or quartz have been definitely recognized. The minerals most commonly associated with the tinstone in the alluvial deposits are topaz, ilmenite, magnetite, rutile, zircon, monazite, garnet, and more rarely columbite, wolframite, corundum, and gold.

The alluvial deposits of the plateau tinfields, all of which in places carry tinstone, may be classified as follows :—

(1) Deposits unrelated to the present drainage system.

(*a*) Deposits of the Fluvio-Volcanic Series.

(*b*) Deposits preserved underneath recent lavas.

(2) Deposits related to the present drainage system.

(*a*) Low terrace deposits with bedrock on the same level as the present stream bed.

(*b*) High terrace deposits with bedrock above flood level of the present stream.

(*c*) Valley flat deposits with bedrock below the level of the present stream.

(*d*) Stream bed deposits in hollows and pockets of rocky channels.

(*e*) Eluvial or detrital deposits.

So varied are the types of stanniferous deposits upon the plateau, and so complex has been the history of the present surface, that almost every square yard deserves prospecting to bedrock. Rich alluvial deposits may occur not only in the present stream beds and banks, but also on the watersheds, on the valley slopes, in buried channels, and in ancient river beds, to which the present topography may afford no clue, while surfaces of bare rock may exhibit areas of primary alteration and mineralization, which, if unremunerative in themselves, may yet indicate the presence of valuable secondary deposits in the vicinity.

THE IRON AND STEEL INDUSTRY OF INDIA

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Introduction.—In this article an attempt is made to give a connected account of the development of the iron and steel industry in India. The first part is mainly historical and deals with indigenous methods. It is followed by brief notices of the early attempts to introduce modern methods which have culminated in the successful enterprises of the present day; and then by a summary of our present knowledge regarding the iron ore resources of India and their relations to its coal reserves. A very extensive literature has grown around the subject, and the following notes are a compilation from the more important papers, published under official auspices and by private workers. It is hoped that such a review will help towards a better appreciation of the promising outlook for the future of the Indian iron and steel industry. The writer is indebted to the authors he has quoted, especially to those whose papers appear in the Records of the Geological Survey of India, and also to the Tata Iron & Steel Co., Ltd., and the Bengal Iron Co., Ltd., who have kindly revised the portions dealing with their works.

The approximate date of the introduction of iron into India, or of its first manufacture in the country, is not known. At the time of Alexander's invasion (326 B.C.) the armed nations of Northern India were as familiar with the use of iron and steel as the Greeks themselves. Quintus Curtius mentions that the chiefs of the Punjab presented Alexander with 100 talents of steel. Archæologists who have studied the prehistoric remains of Northern India believe that the Iron Age may well go back to 1500 or even 2000 B.C. there. The antiquity of the knowledge of iron metallurgy in India may be judged from the rusted implements found in the urn burials of an early period; from the famous pillar at the Kutab near Delhi; from the forged iron bars of the temples of Orissa; from the hammered door panels of ancient shrines and tombs; and from the superb collections of arms preserved by the princes and nobles. Burma is noted for the iron ornaments and balustrades of its pagodas, while the engraving and carving of iron and steel in such articles as armour, weapons, shields, and caskets has been carried on from time immemorial. The pillar at Delhi weighs over 6 tons, is of solid wrought iron of an excellent type, 23 ft. 8 in. in height, 16½ in. in diameter at its base, and 12 in. just below the capital. It is sunk into the ground for 20 in., and there expands into a bulbous form, 2 ft. 4 in. in diameter, resting on a grid of iron bars fastened with lead into a stone pavement. Incised on the pillar is a Sanscrit poem, constituting the epitaph of the Gupta king Chandragupta II, composed in or about A.D. 415. This iron pillar is not unique. There is another, in fragments, which was apparently nearly twice the height of the one just described, at Dhar in Central India. But while the Dhar column bears a Persian inscription of Akbar, incised in A.D. 1591–2, there is no original record on it, placed there when it was set up.

The manufacture of "wootz", or Indian steel, anticipated the cementation process by many centuries, and some authorities believe that it was exported to the west long before the Christian era. There seems little doubt that it was from Indian crucible-steel that the celebrated Damascus sword-blades were made, and these had long enjoyed their reputation for flexibility, strength, and beauty before it was recognized that the alloy from which they were fashioned was produced in obscure Indian villages, whence it was obtained by Persian traders.

Further information on this subject will be found in the *Imperial Gazetteer of India*, vol. ii, pp. 25 and 98; and in *The Commercial Products of India*, by Sir George Watt, p. 692.

The Indigenous Industry.—For information under this heading reference may be made to the following publications:—

(1) V. Ball, *Geology of India*, pt. iii, 1881, pp. 335–416.

(2) Sir G. Watt, *Dictionary of the Economic Products of India*, vol. iv, 1890, pp. 499–520.

(3) Sir T. H. Holland, *Iron Industries of the Southern Districts, Madras Presidency*, 1893, pp. 1–24.

(4) Sir T. H. Holland and L. L. Fermor, *Quinquennial Reviews of Mineral Production in India.*

5 T. H. D. La Touche, [illegible] 1918, pp. 231–81.
6 N[illegible] papers in the [illegible]

Until it almost succumbed in comparatively recent times under the competition of imported metal, the indigenous Indian iron industry was both widespread and prosperous, capable of meeting all the internal demands of the country. There is hardly a single district in India from the extreme south to the Himalayas, or from Baluchistan to the Shan States of Burma, with the exception of the great alluvial plains of the Indus, Ganges, Brahmaputra, and Irrawaddy, where heaps of old iron slags have not been found. Iron ores of high enough grade and in large enough quantities to meet the small requirements of the primitive smelter occur in most of the geological groups, though it by no means follows that all of them are worth consideration from the modern point of view.

Quartz schists carrying magnetite and hematite are very prevalent among the crystalline rocks of peninsular India. In the Vindhyan formations iron compounds are disseminated through immense thicknesses of beds giving rise to the red and brown tints characterizing these rocks.

The ironstone shales of the Gondwana system, in the Damuda Valley, take their name from the limonitic and sideritic ores they contain. Other divisions of the same system elsewhere carry segregations and thin bands of iron ore, utilized in the past by the native smelters. The nodules of ironstone which occur in the Cretaceous rocks of the Trichinopoly district were at one time collected and smelted by the local inhabitants. The rivers draining the Deccan Trap not infrequently deposit magnetite sands derived from these basic rocks. Ferruginous laterites are exceedingly common and their basal layers often form easily worked brown hematites. Such ores have been reduced on a small scale over the whole of India. The Indian smelters in the Himalayan region found their ores in both the Tertiary and the crystalline rocks. On the Shan plateau of Upper Burma residual iron ores occur in the red earth which forms a mantle over a great part of the country, and as gossans to certain veins. But the only deposits which have proved large enough for the requirements of the modern blast-furnace are those of the peninsular Dharwar rocks, though the concretions from the ironstone shales of the Raniganj coalfield were used for some years before being finally abandoned. The ancestral Indian iron-maker, however, drew his supplies from any of the formations mentioned, breaking up the quartz-iron ore schists and concentrating his product by winnowing it in the wind, or washing it in a stream; picking out the richer bits from the ferruginous laterites, or the rusty cement from the ancient sandstones; or panning the sands of the river beds. The Khasias, a hill tribe in Assam, used to obtain their iron ore by the systematic ground sluicing of decomposed granite and gneiss.

In spite of the competition of imported iron goods and of the gradual diminution of the available charcoal fuel, the manufacture of iron by the old, small-scale method still persists in isolated parts of India. In 1913 there were furnaces working in a few districts of Bihar and Orissa, the Santal Parganas, Monghyr and Sambalpur; in the Kumaun Himalayas; in Mysore; in the districts of Malabar, Salem, and Trichinopoly of Madras; in Hyderabad; and in some of the States of Central India. The industry shows signs of greater activity in the Central Provinces than elsewhere, but even there signs of an approaching end are apparent. In 1909 there were 510 small Indian blast-furnaces in operation, but by 1919 the number had fallen to 159. The average annual production of iron for the five years ending 1909 was 557 tons for the whole of the Central Provinces, but no returns are available for later periods.

The principles of iron smelting as carried out by the natives of India are practically the same in all parts of the country, though the dimensions of the furnace and the construction of the blast-producing apparatus vary from place to place. Descriptions of the furnaces have been given by many writers, including Dr. Percy in his *Metallurgy of Iron and Steel* (1864). A useful bibliography has been compiled by Sir Robert Hadfield which brings the list of references to comparatively recent times (see *Journ. Iron and Steel Inst.*, vol. lxxv, 1912, pp. 170–2). The latest paper on the subject is one by Dr. A. McWilliam, who gives an account of aboriginal methods which are still being carried on almost under the shadow of the Tata Iron & Steel Works (see *Journ. Iron and Steel Inst.*, vol. cii, 1920, pp. 160–70).

In the early part of the eighteenth century the industry attained a comparatively high stage of development in the western parts of the Birbhum district of Bengal. The furnaces

are stated by contemporary writers to have been capable of turning out about 35 tons of iron per annum each, which, contrary to the usual practice, was tapped in a molten condition and then refined by a second process resembling puddling. In Malabar, too, at a later period, furnaces up to 10 ft. in height were common. Built from a mixture of red clay and sand, and held together in a stout wooden frame, they were fitted with two platforms in front to support the four goat-skin bellows arranged in pairs, and at the back with a pit into which the molten slag trickled from a slag-hole. In this type a bloom of iron weighing about 5 cwt. was produced in from 48 to 60 hours.

As a general rule, however, the furnaces are much smaller than these, heights of 3 or 4 ft. being common. They are built of clay or of sun-dried bricks, and are conical in form. In front, near the bottom, there is an opening which is stopped with clay while the blast is on, and through which the bloom is removed at the end of the operation. Clay tuyeres are inserted near the base and convey the blast from two skin or leather bellows, worked alternately to keep up a continuous stream of air. A few variations from this general type may be briefly mentioned. Thus the furnace of the Narsinghpur district of the Central Provinces was built across the centre of an oblong pit dug in the ground. Its hearth was made of stone work, and the blast, from bellows of concertina form, was conducted through iron pipes. It is recorded that a suspension bridge was built in 1830 across the

Bias River from iron which had been produced in furnaces at Tendukheda in this district. The Manipur furnaces had their tuyeres inserted at the back, while in front, and opposite to them, was a semicircular opening some 9 in. across through which the products of combustion passed. The upper part of the furnace was only used for feeding in the ore. Remains of furnaces have been found in Upper Burma in banks of firm alluvial clay. They appear to have been used in making iron without the aid of an artificial blast. In Kathiawar the furnaces were of a very unusual shape, being rectangular in section and constructed of brickwork lined with clay. A chimney was built into one end, and close to the opposite extremity were two holes. Through one of these the blast entered, and by the other the slag was removed. A few workers still remain in the isolated parts of the Himalaya Mountains, but their " bloomeries " are much the same as those of the plains. The bellows differed vastly in size and shape in various parts of the country, but were nearly always made of goat or bullock skins, worked either by the hands or by the feet. Indians do not seem to have evolved a mechanical blower such as that used by the ancestral Chinese in their metallurgical operations.

As a rule, only the softer varieties of ore are smelted, and it is the custom to clean and concentrate them before they go to the furnace. The fuel employed is charcoal, and, with the exception of the Waziris who utilized nummulitic limestone for the purpose, no flux is used. When the furnace has been brought to a sufficiently high temperature the ore is sprinkled in at the top, in small quantities at frequent intervals, and alternately with sufficient charcoal to keep the furnace nearly full. From time to time during the blast, which lasts several hours, the slag is removed through a hole which is then plugged up again. At the end of the operation the blast is stopped, the front orifice opened, and the bloom removed. It is refined by re-heating and hammering, often repeated more than once, as the temperature is seldom high enough to cause the liquefaction of the charge. Sometimes the refining is done by the smelters, but more usually they cut the bloom almost in two halves, to display the quality of the metal to the buyer, and sell it in that state, when the further purification is carried out by others. The consumption of charcoal in the Indian process is very high in proportion to the amount of iron obtained, but the metal, by reason of its purity and malleability, has always been held in great esteem by Indian blacksmiths, who use it for the manufacture of all kinds of agricultural and domestic implements such as spades, hoes, ploughshares, sickles, hooks, axes, spoons, and pans. For these purposes it is preferred to foreign-made iron, when it can be obtained readily. At some localities in the Jubbulpore district of the Central Provinces a manganiferous hematite is smelted and a steely iron known as " kheri " made. This is in demand in the surrounding regions, and is welded by the blacksmiths on to the ordinary country-made soft iron to form the edges of knives, scythes, and ploughshares, the striking faces of hammers, and the heads of anvils.

The " lohar " or " agaria ", as the native smelter is called, belongs to the lowest ranks of the proletariat, and although the metal which he makes is sold at a comparatively high price, the bulk of the profit is said to go to the traders through whose hands it passes. On the whole his processess are very inefficient, and the iron turned out bears but a poor relation to the material, labour, and time expended. The " lohar " flourishes longest in the most inaccessible parts of the country, where there is an abundance of timber and an absence of restrictions against its destruction, and where there are difficulties in the way of distributing European iron and steel. Yet the readiness with which foreign articles are obtainable even in the remotest bazaars, and the tempting wages which may be earned elsewhere, owing to the general industrial progress of the country, combine to encourage the iron-makers to desert their hereditary occupation.

Indian Crucible Steel.—Steel is made by the inhabitants of South India either by the carburization of wrought iron in crucibles, or by the decarburization of cast iron. The former product alone is the true " wootz ". The following descriptions of the two processes have been given by Sir T. H. Holland. In the Trichinopoly district the crucibles are made of a mixture of ferruginous clay with charred rice-husk and are about 6 in. in height and 3 in. in diameter. They are charged with pieces of wrought iron, together with 4 or 5% of its weight of wood of the " Avaram " tree (a species of *Cassia*), and with leaves of certain shrubs, and then tightly sealed with clay. Twenty-five crucibles are built up into an arch in a furnace fitted with a tuyere connected to a bellows. After about two hours continuous blast the twelve central

crucibles are removed, having been subjected to a greater heat than those around the sides. By this time the iron is well fused and carburized. The crucibles which are taken out are replaced by fresh ones, previously raised to a high temperature by having been placed on the surface of the arch during the blast, and the process is continued. The charcoal fuel is fed in from below. The finished ingot retains the shape of the bottom of the crucible.

In the Salem district, during the manufacture of wrought iron, certain easily fusible beads of iron are produced and melted off as shot. These are in reality highly carburized particles, or cast iron, and it is from them that the steel is made. A hole is dug in the ground about one foot deep and one foot in diameter. At one side a semicircular groove is cut from the surface to the bottom of the pit. This is separated from the rest of the excavation by a clay partition. The bottom of the small chamber is covered with a layer of quartz. On this an ignited coal is placed and the chamber filled with charcoal. A tuyere, built in with the partition, points downwards and receives the blast from two bellows. The cleaned shot are thrown upon the charcoal and the blast continued for about half an hour, when the process of decarburization is complete, and the tuyere and clay partition are broken down for the removal of the steel cake, which is cooled by sprinkling water on to it and hammered to remove its casing of slag.

Early European Methods.—Failure attended every early attempt to graft European methods on to the native processes and to manufacture iron on a large scale in India. About the year 1825 Mr. J. M. Heath, formerly of the Madras Civil Service, obtained from the directors of the East India Company an exclusive right to manufacture iron on a large scale in that Presidency. In 1830 works were established at Porto Novo in the South Arcot district, with the aid of advances from the Government, and in 1833 the business was taken over by a Company, the works were enlarged, and a new plant established at Beypore on the Malabar Coast. Free mining leases and fuel cutting rights were granted, but in spite of these privileges the undertaking failed. Pig iron made at these works was sent to England and commanded a good price for conversion into steel. A large quantity of it is said to have been used in the construction of the Britannia tubular and Menai suspension bridges. In 1853 a new association, the East India Iron Company, was started. It also held exclusive mining rights over several districts in Madras and erected blast-furnaces at Trinomalai in South Arcot and at Pulampatti in the Coimbatore district. Operations ceased at Porto Novo in 1866, and at Beypore and Trinomalai in 1867.

The history of the attempts made to manufacture iron on a large scale in Bengal is a long one, dating back to the year 1777, when Messrs. Motte & Farquhar applied for the exclusive privilege of smelting iron, and of selling the metal free of duty over a large portion of the province. On their part they contracted to supply shot and shell to the East India Company at Fort William, at four-fifths of the average cost of the same when landed from Europe. In 1779 Mr. Farquhar obtained an advance from the Government to enable him to complete his furnaces, but by 1789 he had relinquished the speculation.

In 1852 Dr. Thomas Oldham, the first Director of the Geological Survey of India, reported on the iron ores of Birbhum and the Damuda valley. The court of directors of the East India Company had especially directed his attention to the question of iron manufacture in connexion with the introduction of railways into India. At this time about seventy native furnaces were at work in Birbhum alone. About the year 1855 Messrs. Mackey & Co., of Calcutta, erected iron furnaces at Mahomed Bazaar in Birbhum and made small quantities of pig iron of superior quality for a number of years before closing down. A final experiment started by Messrs. Burn & Co. in 1875 was soon abandoned. The Kumaun iron works at Kaladhungi in the foothills of the Himalayas, in the United Provinces, commenced operations in 1857, and, after many vicissitudes, failed like all the earlier ventures. Another attempt was made about 1862 at Barwai in Indore, a State of Central India. A Swedish specialist was engaged by Government, a blast-furnace, rolling mill, and charcoal ovens were nearly erected, and a large quantity of ore proved, when Government abandoned the enterprise. The Raja of Sirmur, a State in the Punjab Himalayas, had a blast-furnace and a foundry built in 1867, designed for an out-turn of 75 tons per week. History is silent regarding the progress of the undertaking, but some time later the foundry was converted into a sugar-cane mill!

For all these schemes charcoal was the fuel used, or proposed to be used, and it was not until 1875 that advantage was taken of the

[illegible]

	[illegible]		[illegible]		1919-20.	
	[illegible]	[illegible]	Tons.	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Iron and Steel (Manufactured) ...	495,993	5,492,576	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	95,317	2,019,202
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11,370,686

Indian coal supplies. In that year two large-scale experiments were made at Warora, in the Central Provinces, in smelting rich ore from the Chanda district with the local coal. (In 1839 Messrs. Jessop & Co., of Calcutta, had attempted to smelt Burdwan ore with coke on a very small scale, but the results were inconclusive ; see V. Ball, p. 390.) The results may be described in an observer's words : "The hearth quickly filled with spongy iron which would not liquefy. The blast was intensified and more blank charges of coal added. The temperature in the hearth increased, and the fire-bricks, the tymp plate, and even the bottom of the hearth, were fused ; still the iron that had settled down was so mixed with the ashes of the coal that it would not liquefy, and only kept accumulating till the iron reached the top of the tuyeres, and then a stop was put to all further proceedings till the mass was dug out, which was over a ton in weight." So ended the first attempt to smelt Indian iron ore with Indian coal.

The Barakar Iron Works Co. was formed in 1874. Two furnaces were erected at Kulti near Barakar, each capable of producing 20 tons of pig iron per day. The ores were clay ironstones obtained fron the surface in the neighbourhood of the works. The limestone flux was quarried from crystalline rocks a short distance away, and the principal fuel used was coke made from coal either from the Karharbari field or from mines of the Raniganj field within a few miles radius of the works. The company came to an end in 1879 after producing some 13,000 tons of pig iron. The chief reason for its failure is believed to have been insufficiency of capital. In 1882 the concern was taken over by the Government, and the first blast-furnace was restarted in 1884. In 1889 the works were resold by the Government to the Bengal Iron & Steel Co., who entirely remodelled and gradually developed them, until, with four blast-furnaces, they have to-day a potential output of 10,000 tons of pig iron and 1,500 tons of ferro-manganese per month. The Bengal Iron & Steel Co. completed the erection of a steel plant at Kulti in 1903. The Siemens Martin basic open-hearth furnaces had a capacity of 20,000 tons of steel per annum. The experiment, however, was not successful, and the plant was closed down before 1905. In 1919 the company was reconstituted as the Bengal Iron Co., Ltd.

The successful operations of the Bengal Iron & Steel Co., Ltd., in the later stages of its career under that constitution, mark the establishment of modern iron metallurgy in the Indian Empire on permanent foundations, and the next step in building up the industry was the inauguration of the Tata Iron & Steel Co., Ltd.

INDIAN IRON AND STEEL TRADE. Before considering its rise and development it is advisable to glance for a moment at the iron and steel trade in India generally. In 1912, the year in which the blast-furnaces of the Tata Company were completed, India's domestic production of iron amounted to about 50,000 tons per annum, while her requirements of iron and steel may be gauged from the imports in the same year, which totalled upwards of 700,000 tons covering a great diversity of products. In the last twenty years there has been a very remarkable increase in the consumption of iron and steel in India, though the import trade suffered a general set-back during the war. The above table gives the quantity and value of the heavy iron and steel imports for the fiscal years ending March 31 in 1912, 1914, and 1920.

In this table manufactured iron includes angles, rods, bars, channels, and bolts. The steel manufactures include similar products, together with ingots, blooms, billets, and cast steel in addition. The undifferentiated iron and steel articles comprise beams, pillars, girders, hoops, strips, rails, chairs, sheets, plates, wire, nails, rivets, etc. A consideration of similar statistics for the quinquennial period 1913–18, in which allowances are made for the domestic production, for exports and re-exports, leads to the conclusion that India's consumption, during a series of years in which her industrial development was retarded by the war, was in the neighbourhood of one million tons per

annum. There is every reason to believe that this figure will show a rapid rate of increase in the future.

Yet the articles which have just been enumerated by no means represent India's total imports of iron and steel goods, and to gain a more accurate appreciation of the true position, the more highly finished articles such as machinery, railway plant and rolling stock, hardware and cutlery, have to be taken into account. Adding the values of these to the values of the heavy goods of the above table, the totals become as follows :—

Years.	Total Value of Iron and Steel Materials. Approximately.
1912	£16,000,000
1914	£27,000,000
1920	£25,000,000

The manufacture and rolling of Indian steel was successfully established about the end of 1913, after the usual preliminary difficulties, always met with in the introduction of complex metallurgical processes into new countries, had been overcome. Before the war Indian pig iron had been shipped to Burma, the Straits Settlements, Ceylon, Java, Manchuria, China, Japan, Australia, New Zealand, the United States, and South America. During the war export was prohibited, and the whole output of Indian rails from the Tata works was taken by Government for military purposes in Mesopotamia, East Africa, and Palestine, a portion being even shipped as far as Salonica. Shell steel was supplied to the Indian munition works, and both the Tata works and the Bengal Iron Co. made ferro-manganese on a large scale.

THE TATA IRON & STEEL CO., LTD.—Jamsetji Nusservanji Tata, a member of the priestly caste of the Parsees, who was born in the State of Baroda in 1839, was the first Indian to realize the possibilities of an extensive iron and steel industry in his native land, and he also possessed the foresight to visualize the potential developments which have since come to pass. The operations of the Bengal Iron & Steel Co., Ltd., had already proved beyond question that pig iron could be made profitably in India, and it remained for Mr. Tata to institute the second iron-manufacturing concern and to introduce modern steel works and rolling mills.

The Tata Iron & Steel Co., Ltd., was formed in 1907 with a capital of Rs. 2,31,75,000 (£1,545,000). To-day it has an authorized capital of Rs. 10,52,12,500 (£7,014,166), of which Rs. 3,98,04,570 are issued. After preliminary investigations in India, Europe, and America, Mr. Tata engaged Mr. C. P. Perin, of New York, as his consulting engineer. The latter's associate, Mr. C. M. Weld, arrived in India in 1902, and for some years examined various iron ore deposits, many of which had been discovered in the first instance by the officers of the Geological Survey of India. The earlier work was carried out in the Central Provinces, and large reserves of excellent ore were proved, but the forest resources of that region did not prove big enough to warrant the establishment of a charcoal iron works there. The surveys were then continued further on towards the east, in order to approach the coalfields of Bengal more closely, and finally the deposits of Gurumaishini in Mayurbhanj were chosen as the source of the iron ores.

The works are situated at Jamshedpur (formerly known as Sakchi), adjoining Kalimati station on the Bengal-Nagpur Railway. This place is 154 miles west of Calcutta, about 115 miles from the Jherria coal mines, 100 miles from the limestone quarries, and 45 miles from the Gurumaishini iron ore mines. The following description of the Tata works is compiled from papers by Messrs. Perin, Tutwiler, and Surtees Tuckwell. The writer is especially indebted to the last-named for his kind assistance. Construction commenced in 1908, and the Sakchi jungle was rapidly transformed into a town, which now promises to become the centre of one of the leading industrial regions of Asia.

The two original blast-furnaces of the company, each 77 ft. high and 19 ft. in diameter, with a capacity of 200 tons of pig iron per day, were blown-in in November, 1911, and September, 1912, respectively. Each furnace is equipped with up-to-date charging apparatus and four Cooper-Kennedy stoves. These two furnaces have since been enlarged to turn out 280 tons per day each. The shortage of ferro-manganese in India during the war led to the rapid erection of a third furnace of a somewhat smaller type in 1919. At the present time two of the most modern skip-filled furnaces, with a capacity of 600 tons per day each, are nearing completion.

The original coke-oven plant consisted of 180 Coppée non-recovery ovens. To these have been added a battery of fifty Koppers by-product ovens and a Simon Carves

sulphuric acid plant, which supplies the acid necessary for the production of sulphate of ammonia. Three batteries of Wilputte design, each containing fifty ovens, are being added, together with extensions to the coal tar, ammonium sulphate, and benzol recovery plants. All the silica shapes requisite for the construction of these new ovens have been made in India by the Kumardhubi Brick Co.

The steel works plant consists of one 300 ton mixer, which receives the molten pig iron from the blast-furnaces before it is charged into the open-hearth furnaces. There are seven of the latter, four of which have a capacity of about 55 tons per heat and three of 75 tons capacity. These enable an output of 27,000 tons a month to be maintained. The new steel plant includes two 25 ton Bessemer converters, two 100 ton tilting open-hearth furnaces, and one 1,300 ton mixer. The converters will remove all the silicon and as much carbon as is desired from the iron, leaving the tilting furnace the duty of removing the phosphorus and sulphur and bringing the iron to the required percentage of carbon. The elimination of these elements is said to reduce the time necessary for the finishing of a heat in the tilting furnace by about 75%. The large mixer is being erected to store the hot metal from the blast-furnaces over the week-ends, when the open-hearth plant is not working. The present 300 ton mixer is to be used as an additional open-hearth furnace after the new mixer is built. Provision has also been made for the installation of a 250 ton recarburizing mixer, a third converter if necessary, a third duplex tilting open-hearth furnace, and three Heroult electric furnaces for the manufacture of special steels or ferro-alloys.

There are four soaking pits in the steel works, equipped with mechanically operated lids, and an electric overhead charging and drawing crane. The ingots are made 21 in. by 19 in., and weigh between 2 and 3 tons each. They are removed by a self-tipping electric trolley to the mill tables.

The blooming mill consists of a 40 in. mill, operated by a Galloway engine of 11,000 h.p. In this mill the ingots from the soaking pits are made into blooms and billets. Another 40 in. reversing motor-driven blooming mill with hydraulic manipulator and followed by hydraulic shears is being added.

The present 28 in. finishing mill has three sets of rolls, and is worked by a 12,000 h.p. engine. It is capable of turning out rails from 100 lb. to 30 lb.; beams from 15 in. by 6 in. down to 5 in. by 3 in.; angles from 6 in. by 6 in. to 3 in. by 3 in.; and channels from 12 in. by 4 in. to 6 in. by 3 in. The blooms from the blooming mill are reheated before they are rolled, and the sections of rails or structural materials, after being rolled to the required dimensions, are cut by circular saws into the necessary lengths, and are conveyed mechanically by rollers to a cooling bed of the moving type. From the cooling bed all the bars and rails are passed through straightening machines in the finishing department, which also contains the usual planing and drilling devices. The products are handled by an overhead electric crane. The motor-driven blooming mill will serve a new 28 in. to 30 in. combination rail and structural mill.

There is one 16 in. bar mill making light rails weighing 30 lb. to 14 lb. to the yard; angles of all sizes from 3 in. to $1\frac{1}{2}$ in.; channels from 4 in. to $1\frac{1}{2}$ in.; beams of 4 in. by $1\frac{3}{4}$ in.; and fish-plates for rails. There are also two 10 in. mills devoted to the production of lighter sizes of flats, squares, and rounds. The new bar mill is of the latest continuous type, and will take billets from the sheet, bar, and billet mill at present under erection. Independent motor-driven rolls are being added for the production of wire rods.

The plate mill is now nearly completed in a separate building over 1,000 ft. long and about 100 ft. wide. The mill will produce plates from $\frac{1}{8}$ in. to $1\frac{1}{4}$ in. thick in various widths up to 96 in. and various lengths up to 50 ft. It is to be driven by a 2,000 h.p. motor taking alternating current at 3,000 volts, and is provided with four bottom-type reheating furnaces. The building also contains the straightening and shearing machines for the plates.

The sheet, bar, and billet mill is in direct line with the new blooming mill, and will roll billets from $1\frac{3}{4}$ in. square to $6\frac{1}{2}$ in. square for the bar mills. It will also roll sheet bars up to 8 in. wide for the sheet mill. It is proposed to finish steel sleeper sections up to 16 in. wide on this mill.

The sheet bars will be delivered from the mill just described to the sheet mill proper, where six special furnaces will reheat them. The rolling equipment consists of two jump rolls, two balanced rolls, six finishing mills, and two cold rolling mills,

all driven by a 4,000 h.p. motor taking alternating current at 3,000 volts. This mill will produce sheets to any width up to 38 in., and of any thickness desired from ⅛ in. down to 0·01 in.

The present scheme of extensions also contemplates a wire mill capable of producing 20 tons of miscellaneous sizes of wire per day of 24 working hours, to be used for fencing, wire-netting, nails, etc. ; a bolt and nut shop with a sufficient number of machines to produce 50 tons per week ; a steel sleeper press ; a cast-iron pipe foundry ; and a new roll-turning shop. A large new machine-shop is under erection, in which the housings, castings, and the bulk of the heavy components for the new rolling mills, etc., are now being made. In addition there are shops for pattern-makers, carpenters, blacksmiths, locomotive repairs, electrical repairs, and structural shops for bridges, roofs, and buildings.

The power-house contains three turbo-blowers, which supply 32,000 cubic feet per minute to the blast-furnaces under a pressure of 15·5 lb. per square inch. The plant consists of two 1,000 kilowatt and one 1,500 kilowatt, 3,000 volt turbo-alternators, running at a speed of 3,000 revolutions per minute, and three transformers of 1,250 K.V.A., 3,000 to 440 volts, and two motor generator sets of 500 kilowatts each.

To supply the power for the new extensions, the whole of which will come into operation progressively within the next two years, large additions to the former power-plant have been necessary. These include a large range of new boilers, fired with blast-furnace gas, three 5,000 kilowatt turbo-generators, one 4,200 kilowatt turbo-generator, one 2,000 kilowatt generator, one 2,000 kilowatt mixed pressure turbine, the steam for which is principally obtained from the existing rolling mill engines, and the necessary transforming equipment to step down from high to low tension. Corresponding increases have been arranged in the water system, pumping plant, the transporting department, laboratory, offices, etc., to say nothing of the essential augmented reserves of raw material.

When the present extensions are completed, the Tata iron and steel works will have a potential output of 700,000 tons of pig iron and 580,000 tons of steel ingots per annum. Of the latter, it is proposed to convert some 426,000 tons into finished and semi-finished products, and the whole of the new plant has been so laid out that future extensions may be added with the least inconvenience.

The company owns its own collieries, iron ore mines, manganese ore mines, wolfram mines, and limestone and magnesite quarries. It also holds a large interest in the Kumardhubi Silica & Fire Brick Co., Ltd., which makes silica bricks from the gannister deposits of the Gaya region, magnesia products from Mysore magnesite, and other refractories from fire-clay, chromite, etc. The Tata Company to-day finds employment for 25,000 men and women, and, as it is still the custom of the ignorant to underestimate the capability of the Indian workman, it may be pointed out that the management has gradually been able to reduce the number of European and American employees and to substitute Indian labour. For example, in the bar mill, three eight-hour shifts, which would necessitate the employment of twenty-seven Europeans, are manned by a crew of twenty-five Indians, who run the plant economically with only two European superintendents. In other departments similar reductions have been made. Out of 137 covenanted Europeans and Americans, 75 are employed as supervisors at the steel furnaces and rolling mills, which between them find employment for 4,200 men. At the blast-furnaces there are only 8 Europeans to 1,600 Indians ; in the mechanical department 6 to 3,000 ; and in the traffic department only 1 to 1,500. The chemical laboratory originally employed five European chemists. Now the chief and the assistant are Europeans, the remainder of the staff being twenty-one Indians. According to Mr. H. Surtees Tuckwell, " in very many instances Indian workmen have shown themselves possessed of extraordinary skill and manual dexterity, and the electrical department is under the superintendence of an Indian gentleman, a graduate of an Indian University, assisted by a staff of Indian wiremen and electricians." The coke-oven department is also under the sole charge of an Indian. Social welfare work among the employees is actively undertaken at Jamshedpur, which is a well-laid-out town possessing a modern water supply and sanitation system, hospitals, schools, and recreation grounds.

(*To be concluded.*)

BOOK REVIEWS

Recent Practice in the Use of Self-contained Breathing Apparatus. By Lieutenant Rex C. Smart. Cloth, octavo, 310 pages, illustrated. Price 15s. net. London: Charles Griffin & Co., Ltd.

The title does not fully indicate the character of this valuable work, for the book goes far towards being a textbook on mine rescue organization and the training of men in the use of breathing apparatus. As officer in charge of the First Army Mine Rescue Station, B.E.F., the author had exceptional opportunities for the study of mine rescue work under the severe conditions of military warfare. His record of experiences in the employment of breathing apparatus should be of general interest to mining engineers and of considerable value to those connected with rescue stations. The subject is treated from a military standpoint, but though there are such references as " Pails Mark I and II ", " as per A.F. W. 3419 ", and " the O. i/C. School ", the book generally is free from military jargon, and civilian readers will have no difficulty in following the text.

It was essential that appliances on any portion of the army front should be standardized as far as possible. The author gives brief notes on leading types of rescue appliances, but the only appliances dealt with in detail in this work are of the Proto, Salvos, and Novita designs.

The account given of the course of training for tunnellers of the Royal Engineers at the Mines Rescue School in 1916–17 suggests that the holder of a certificate of competency from that training centre would be able to do work equal to that of the most efficient members of English colliery brigades at the present time. Lieutenant Smart gives full details of the tests for proficiency and the examinations at the schools, and the questions may be studied with advantage by any member of a mine rescue team. As illustrating the searching character of the examination, we may say that there are given 16 questions on the rubber bag and its contents in dealing with the Proto apparatus, and under the heading of pressure gauge valve 21 questions might be submitted to a candidate.

Points to be observed in adjusting the apparatus and notes on repairs form a valuable feature of the publication, and the tables of statistics relating to stocks and parts of apparatus repaired, as illustrations of efficiency in organization, should be of service to those who have to arrange the office routine of a rescue station on a large scale.

The section on the charging and testing of apparatus is well written, but the illustrations of oxygen cylinders are not so clear as is desirable. A system of air and water circulation is generally better shown by plain line diagrams, such as the author employs for illustrating the design of valves, than by reproductions of photographs of assembled fittings.

Physiological considerations connected with the use of respiratory apparatus are dealt with in an able manner, but in several instances expressions might be modified to the advantage of the general reader who would probably understand references to heart-failure and difficulty in breathing more quickly than he grasps the purport of the statement that " men may suffer from oxygen deficiency syncope without dyspnœa symptoms ".

Considerable attention is given to the phenomena of gas explosions. The effects of explosions in collieries are generally complicated by the presence of finely divided coal. There was no possibility of inflammable dust being present in the galleries on the army front, where gas explosions occurred, and data on effects of force and other features are worthy of record for comparative purposes in the study of explosions underground.

Methane or firedamp (CH_4) may be one of the products of the detonation of nitrocellulose, but the most dangerous gas derived from gun-cotton, ammonal, and other explosives used in military mining was carbon monoxide. After the explosion of a charge, which frequently amounted to many tons of explosive, the enclosing strata were likely to be saturated with noxious gases. The effect was particularly noticeable with " camouflets ", that is, where the charge of explosive was not sufficient to break through to the surface of the ground, no mine crater being formed. The gases occluded in the rocks discharged themselves into the galleries, which stood open after the mine was fired, and secondary explosions resulted in many instances from the ignition of gases by candles. Plans are given showing areas of workings affected by explosions of this type. They appear to be very local in character, although in some cases considerable force was developed. The author

notes occasions where a succession of explosions occurred at regular intervals of two or three minutes duration.

In dealing with the features of carbon monoxide poisoning it is stated on the authority of Marshall, p. 577, that miners' phthisis was due principally to carbon monoxide poisoning in the South African gold mines. This is not in accordance with the views of leading authorities on miners' phthisis, a matter which has received considerable attention from those connected with the gold-mining industry. Inhalation of noxious gases may have influence on the resistant power of the lungs, but the presence of fine silicious dust in the atmosphere is almost universally regarded as the primary if not the sole cause of miners' phthisis on the Rand.

As the equipment of a mine rescue station is not complete without a supply of small creatures for testing the purity of air, Lieutenant Smart gives notes on the care of mice and canaries in the concluding section of his work. We learn that oxymel of squills may be given with advantage to birds suffering from bronchitis, and what is a good design of cage for the housing of mice. As a sidelight on the thorough nature of military organization, we learn from another portion of the book that mice may be regarded as units on the strength of a company, for the stores drawn from ration dump include: Bread (for mice), one loaf per day for 25 mice; milk (for mice), one tin per day for 25 mice.

Although military organization as described by Lieutenant Smart may not be necessary for civilian work, we would call attention to the remarks made by Professor Sir John Cadman in a foreword to the book under review. He says: "It is clear that rescue work in collieries would be conducted more efficiently and with less danger by the application of some, at least, of the rules and regulations and by the adoption of the standardized system of training which were employed by the military authorities in connexion with the rescue operations conducted by the Tunnelling Companies of the Royal Engineers during the war."

Wherever noxious or irrespirable gases may be met with, rescue apparatus is a necessity, and in dealing with warehouse fires, gas undertakings, coke-ovens, and chemical works trained men equipped with self-contained breathing apparatus may be able to save life and property. Lieutenant Smart has written a book which will go far towards supplying the needs of those who desire to study self-breathing apparatus and the organization of mine rescue work. In these times of trade depression it is gratifying to note that Messrs. Charles Griffin & Co. have added so valuable and original a volume to their well-known series of textbooks for mining engineers.

STANLEY NETTLETON.

The Tin Resources of the British Empire. By NORMAN M. PENZER, M.A., F.G.S. Cloth, octavo, 350 pages. Price 15s. net. London: William Rider & Sons, Ltd.

This book is a compilation of extracts from articles and bulletins by some of the leading geological and mining authorities on tin, and gives in a concise and attractive style all the known localities within the British Empire where tin occurs. While the author acknowledges his indebtedness to these various authorities, the work would carry greater weight if quotations and extracts were more clearly defined instead of leaving the reader in doubt as to which parts, if any, are written from the author's own experience.

The book opens with an introduction giving a brief historical sketch of the etymology of the word "tin", and its early sources and uses, together with a list of the ores containing tin. Chapter II deals with the geology and occurrence of tin in the United Kingdom, with special reference to the principal mines in Cornwall and Devon, now unfortunately closed down owing to the depressed state of industry. Of geological interest is the occurrence of tin in Scotland and Ireland, but in neither case are they of economic importance.

A large part of the book is taken up by Chapter III, relating to the tin-producing British possessions in Asia, one of which alone, Malaya, has by far the largest output in the world. The author deals thoroughly with this important section under different headings, but one cannot leave unnoticed some few inaccuracies that appear. On p. 56 it is stated that "malaria is not common", whereas it is very common, but fevers of the malignant type are rare, and consequently the mortality is low compared with other tropical countries. Under "Methods of Mining" the word "lampan" is bracketed with "dredging", from which one would naturally infer that "lampan" is the

equivalent of "dredging", whereas it means "ground sluicing". Muddy water does not assist concentration, as the author states on p. 73, but rather impedes it, while the statement on p. 77 that wolfram is removed from tin-tungsten concentrates by means of a horse-shoe magnet is an error which should not have been allowed to creep in. Dredge buckets, too, are usually seven to twelve rather than ten to twelve cubic feet capacity.

Several interesting photographs illustrating the methods of working are given and the section ends with a number of tables of output, charts of production and export of tin over a period of thirty years, and a glossary of a few Malay-Chinese words used in mining.

Of the Indian Empire the Burma deposits are, as the author points out, the most important, while, apart from geological interest, the tin occurring in Bengal and Bombay is negligible. Interesting historical and geological data are given of the Mergui and Tavoy districts, development of which has been slow owing to the lack of means of communication, but according to the table on pp. 146 and 151 a pronounced increase in the output is noticeable in recent years.

The African colonies and the newly acquired "German South-West Africa" are dealt with in Chapter IV, with Nigeria as the most important producer. Here the deposits are in many respects similar to those of Malaya, though by no means so rich or so extensive, and their development was retarded by labour and climatic conditions. In the historical sketch the author states that it was in 1884 that tin was first brought to the notice of the Governor of Northern Nigeria, though from the table showing the output it was only in 1907 that tin was mined in any quantity. He attributes this delay to the public being slow in taking advantage of the situation (p. 161), but he might have also added to a great extent to the lack of sympathy shown to the industry by the Government, who failed to realize that the miner is one of the forerunners of civilization. Since this book was written, representations made to the Government to help the industry have received favourable consideration, and the promised construction of additional railway lines will greatly assist the development of deposits now too far distant for profitable exploitation.

In Chapter V Canada is mentioned on the meagre evidence that tin has been found there, but this chapter could well have been omitted from the book. Tin has doubtless been found in other British colonies, but this would hardly justify their inclusion in the book as being important to the resources of the British Empire.

Chapter VI deals with Australasia. The various tin-producing countries are well described, and the accurate maps are helpful in following the description of the fields. The latest statistics of the Commonwealth are not complete, but there is a distinct falling off in the output.

Chapters VII and VIII describe the industrial application of tin and prices of the metal, ending with a table of the world's output, which might have been brought up to a more recent date than 1917. The heading of the table "Tin Ore (Tin Content)" on p. 294 is misleading, as the figures relate to either the quantity of metal produced or to its equivalent in the ore, and not to tin ore.

The unprecedented demand for tin, created by the war, caused its price to rise to a fabulous figure, which acted as an incentive to increased production, more especially in those countries unaffected by the high taxation to which companies operating in the British Empire were penalized. The result was a large increase in the production of tin in foreign countries, which reaped all the benefits of the high prices. Thus, while in 1914 the production in the British Empire amounted to 57%, in 1918 when the price had risen to close on £400 per ton, the production had fallen to 44% of the world's total output. This high-water mark in the price of tin was reached in the early part of 1920, when the metal sold for £419 per ton, and the subsequent decline to the present level, far below the cost of production, has caused a falling off of the output which is bound to be reflected in an advance in the price so soon as the industrial world returns to more normal conditions. The statistical evidence presented shows this gradual decline in the production of tin in the British Empire, and therefore great efforts will be needed to retain the supremacy in the world's supply which we have held in the past.

An excellent bibliography completes an interesting and instructive book, which should prove helpful both to the general public and to the student in acquiring a knowledge of the tin resources of the British Empire. A somewhat similar work on the Tin Resources of Foreign Countries, as foreshadowed in the general introduction, would fill a much-felt want. HENRY BRELICK.

Field Methods in Petroleum Geology. By G. H. Cox, C. L. Dake, and G. A. Muilenburg. Cloth, octavo, 310 pages, illustrated. Price 24s. net. New York and London: McGraw-Hill Book Company.

The progress of modern methods in field geology as applied to oil-finding has been extremely rapid of latter years, more particularly since the value of scientific investigation of petroliferous areas has become generally recognized. The tendency has undoubtedly been towards the creation of a highly specialized field technique, involving an intimate knowledge of accurate geological mapping, a knowledge only attained after extensive personal experience. The opening up of several new areas all over the world has further necessitated the initial construction of topographical maps as preliminary to geological work, and in many cases the geologist has had to act as his own surveyor, usually a matter of regret, though not without obvious advantages in many cases. It follows, therefore, that the training of an oil-geologist must at least include instruction in the first principles of surveying, in order that, if need arise, he may be able to use the ordinary instruments necessary to the production of a topographical map on which to base his future work. We are thus able to appreciate the reason of the two distinct sections into which the present volume is divided, the first dealing with instruments and instrument methods, and the second with the structural geology of petroleum, including identification of structures and general field operations.

The chapters on surveying are, if anything, more lucid and comprehensive than those devoted to actual geological field work; from the antithetical nature of the two sciences this was rather to be expected, since any discussion of field methods, unless extensive, is bound to lend itself to much adverse criticism from the very nature and magnitude of the subject. The proof of this lies in the fact that no really exhaustive treatise on structural geology has ever been written, and if it were it is doubtful whether it could adequately replace even a part of that training which actual field experience gives, and from which ability and competence can alone be won. The authors have attempted a very ambitious task in the production of this book, and although it certainly fills a gap in technical literature as intended, it hardly comprises a "satisfactory systematic discussion of the minutiæ of field procedure" (to quote the preface), even applied to oil geology. Such a discussion, if at all feasible, would fill a book many times the size of this little volume.

In the chapter on instruments, compasses, levels, barometers, alidades, levelling and stadia rods, and the plane table all receive careful treatment, and, as concise descriptive matter, this is a very commendable part of the book. The succeeding chapter is devoted to the various methods of usage of such apparatus in actual practice, and contains ample information for those unaccustomed to the handling of instruments of this description. The important initial determinations in oilfield work are those of direction, distance, and elevation, and the methods discussed rightly eliminate all details having no direct bearing on these points.

Preceding to the geological section of the book, we are at once struck by the narrowness of view taken by the authors in their treatment of the subject; for example, a statement appearing on the opening page (129) of this section reads as follows: "The field-work of a petroleum geologist is confined largely, and in wild-cat territory, almost wholly, to the working out of structural conditions of folding and faulting; in other words it is made up largely of a search for anticlines and terraces, and of the mapping of such areas." Such a statement, more especially the latter part, is not only elementary, but it shows a decided lack of imagination, to say the very least. When geologists confine their attention solely to the location of anticlines or terraces, then they may as well retire from the field altogether; if the experience of the last decade gained from many parts of the world is simply bounded by the word "anticline", it is not only a poor outlook for future oil exploration, but is at the same time a doubtful reflection on the standard of work carried out. To be of real and universal value any discussion of suitable oilfield structures and their identification should be, if not actually comprehensive, at least broad and constructive, and to narrow the possibilities down is simply to evade the wider questions.

Under the heading of field operations is included a great deal of miscellaneous information of value to a field party, as contributing both to the success of the work and to the welfare of the individual.

The volume contains a glossary of technical

terms, and also an appendix including tables of natural functions, stadia tables, temperature corrections for altitude scale, etc. In addition, there is an introduction which, in eleven pages, disposes of the origin of oil and gas, reservoirs, migration, and structural conditions favouring accumulation; the diagrams illustrating these features, showing inclined water, oil, and gas zones in some cases are indeed difficult to follow.

H. B. MILNER.

Primer on the Storage of Petroleum Spirit and Carbide of Calcium. By MAJOR A. COOPER-KEY, C.B. Second Edition revised. Cloth, octavo, 140 pages. Price 5s. net. London: Charles Griffin & Co., Ltd.

The general utility and public appreciation of this little handbook on the storage of petroleum are proved by the issue of this second edition, in which the author has revised certain parts of the text, bringing it both legally and technically up to date. The success of a publication of this description is not at all surprising, since it seems to be a curious feature of English law that, although framed for the protection and well-being of the community at large, a species of popular edition of any particular Act or Order has to be written before the tenets thereof can be grasped by the public directly affected. Usually the niceties of legal terminology and the quaint complexities of phrasing leave the layman in a perfect maze of doubt and incomprehensibility on perusal of the official documents, and it is not until his favourite newspaper gives an intelligible account, or a readable annotated version of its purport is published, that he really knows exactly what to do and what not to do. Thus, on matters pertaining to the conveyance and storage of petroleum, petroleum products, benzol, and similar inflammables (including acetylene and calcium carbide also discussed here), there must obviously be no misapprehension, since the risk of fire or explosion, particularly in densely populated districts, and the possible disasters attendant on carelessness of keeping or handling such materials, are too great to allow of any evasion of regulations through lack of understanding.

The great fillip accorded to the motor industry as a result of the war has tended to an enormous increase in the number of persons using petroleum products both in commercial and private interests; consequently a great deal more motor-spirit is privately stored than was the case a few years ago. The Act allows the ordinary consumer to keep sixty gallons in a suitable store-house, subject to the regulations made by the Secretary of State under Section 5 of the Locomotives on Highways Act, 1896, full details of which will be found in Appendix V in the present volume. The majority of people, we are sure, are conscientious in the matter of carrying out the necessary regulations, but there is always that casual minority, who either through ignorance or selfish disregard for the safety of others, declines to worry about such "trifles" as regulations, and in this case the allowance is just sixty gallons too much. The truth of the old adage that "familiarity breeds contempt" never received more cogent proof than from the long record of accidents resulting from careless handling of oil; chauffeurs as a class are particularly remiss in this respect, and we welcome the author's eight "Dont's" for their guidance. Such a practice as smoking while replenishing petrol tanks, for example, is of common occurrence; in nine times out of ten nothing untoward happens, but there is always the tenth chance.

In this book the preliminary chapter deals with oil and flash point determinations in so far as these affect the legislative control of oil. There follows a chapter on the storage of oil without licence, in essence a lucid explanation of the existing regulations. The author also deals with the various aspects of bulk storage and of the licences issued for this purpose by the local authority; the treatment of these questions is very excellent, because some valuable personal suggestions are embodied in the text, making it comparatively easy for petroleum inspectors and others to carry out their duties in the best interests of all concerned. Such features as site, construction, mode of storage, quantity permissible under particular circumstances, conveyance, and garage supplies are all adequately discussed, together with the sound modern plan of underground storage, a method finding favour with many large commercial firms at the present time. In the last chapter on future legislation, a variety of matters are discussed in which criticism and suggestion play an important part; the paragraph on tank-ships ("tankers") might well have been extended from the

point of view of general information ; it is surprising how few people have any idea whatever of the nature of the vessel conveying oil from one country to another.

Finally, the inclusion of a chapter on acetylene and calcium carbide, their properties, storage, uses, and dangers, and also the paragraphs dealing with existing legislation in regard to these matters, are entirely relevant to a book of this description. The probability is that at least 70% of motorists use acetylene lighting at the present time, despite the many obvious advantages of electricity ; under these circumstances the use and storage of calcium carbide are, with the acetylene to which it gives rise, subjects just as worthy of careful consideration and regulation as petroleum.

H. B. MILNER.

☞ Copies of the books etc., mentioned under the heading "Book Reviews" can be obtained through the Technical Bookshop of *The Mining Magazine*, 724, Salisbury House, London Wall, London, E.C.2.

NEWS LETTERS

BRISBANE

March 30.

ROMA OIL GEOLOGY.—For the last year or so Dr. H. I. Jensen has been studying the geology of the Roma district in South Queensland, 300 miles west of Brisbane. This is the locale of the much-discussed and celebrated Roma bore, which is being sunk by the State authorities. A report by Dr. Jensen has this month been published by the Queensland Department of Mines. He has, since May, 1920, been investigating the geology of a considerable area of country north of the Western Railway between Roma and Mitchell. So far, the examination of the country has been carried north to the Carnarvon Range, where the tributaries of the Comet River rise, and to Crystalbrook and Eddystone Vale stations, roughly 100 miles north of the Western Railway. The work has been beset with difficulties owing to the scarcity of rock outcrops over considerable areas ; nevertheless, the main features of the structure of the region have now been disclosed. A full account of the country with geological details is being prepared for publication as a Bulletin of the Geological Survey. A brief résumé of the principal results of the investigation are given herewith.

The geological formations embraced in the area examined are : (1) the Ipswich series of the Jura-Trias, consisting of sandstones, shales, calcareous shales, limestone (impure), and calcareous tuff occupying a fringe along the extreme north of the area, and dipping south-west under (2) the Bundamba series (also Jura-Trias), consisting principally of sandstones, mostly of a siliceous type, conglomerate and some intercalated shale ; this latter series spreads over the greater part of Pony Hills, Westgrove, Merivale, Crystalbrook, and Eddystone Vale stations, and dips southerly and south-westerly under (3) the Walloon (also Jura-Trias) series, which extends from Forest Vale, Toolumbilla, Mount Hutton, Myall Downs, and Durham Downs stations on the north almost to the railway line between Roma and Wallumbilla, and to within 12 miles north of the railroad between Amby and Mitchell. South of the Walloon there is (4) the Cretaceous Marine. Areas of rock which has been assumed to be (5) Upper Cretaceous, on the ground of lithological character and stratigraphical position, but destitute of fossil evidence, have also been determined north of Mitchell ; and (6) the basalts of Mount Hutton and the Dividing Range have been mapped more accurately than hitherto.

In Bulletin 247, p. 17, Mr. W. E. Cameron estimates the dip of the Trias-Jura beds under the Roma region at between 150 ft. and 200 ft. in the mile towards the south. In the present investigation the average southerly dip in large areas of massive sandstone on the Dividing Range north of Orallo was found to be somewhere between 1 in 45 and 1 in 50, that is, between 105 ft. and 120 ft. in the mile. Observations in the field on Crystalbrook and Eddystone Vale stations gave the southerly factor of dip as 60 ft. in the mile for this region.

In a section prepared an average dip of 1 in 50, or about 100 ft. to the mile, to the south was assumed. It was noticed that this brings the gas zone at the bottom of the Roma bores into the heart of the Injune Creek coal area or Lower (calcareous) Walloon division. In fact, the Roma gas zone seems to coincide with that of the "bore-hole coals" passed through between the surface and 400 ft. in depth in Nos. 3 and 3A water bores on Mount Hutton subdivision, about 8 miles west of the 51 mile on the Injune Railway. A comparison of the strata passed through in these bores and those of the Roma bores shows that both consist of a rapid alternation of shale, carbonaceous shale, sandstone, and limestone, with occasional hard streaks, cements, etc., with this difference, that the Injune sections show

frequent intercalations of coal as well. The rapidly changing nature of the deposits indicates formation under estuarine and deltaic conditions, therefore favourable for the production of oil. The two Injune Creek bores referred to also yielded gas, which, however, on analysis, proved to be coal gas.

Inasmuch as Cunningham Craig has shown in the case of the Trinidad field, and other geologists for other fields, that a coal series may within a few miles change into an oil series, there is no objection to the correlation of the Injune Creek coal beds with the Roma gas zone. In fact, all the geological evidence collected points to the identity of the two zones. Thus, the rocks actually met with in the field passing north from Roma, and plotted on a section assuming the average dip of about 100 ft. to the mile, give almost the same thickness of each horizon passed through as in the Roma bores. In reality the dip is not as regular as assumed above. Field work shows that the entire region is folded into gentle anticlines and synclines on approximately north-south axes, and that there are a series of monoclines and flattenings, or terraces passing from south to north which have developed on east-west axes.

To deal first with the rolls on north-south axes, it may be mentioned that there are indications of a syncline of a very gentle nature between Roma and Wallumbilla. Roma is near the axis of a gentle anticline, but would appear to be slightly (perhaps 3 to 4 miles) east of the actual centre. A broad syncline has its centre near Muckadilla, as shown both by the curvature of the Cretaceous Walloon border north of Muckadilla, and by the section of the Muckadilla bore. Another anticline has its axis a few miles west of Amby, but there are indications of a severe north-south fault, with downthrow to the west, between Amby and the sharp bend in the Dividing Range. This downthrow moves the boundary between the Cretaceous and Walloon many miles north of where it otherwise would be.

As regards the monoclines or terraces, there is a very decided flattening of dip at Orallo and Cornwall about 30 miles north of the Western Railway. There is a slight increase in dip from the 35 mile to the 50 mile, and a great flattening between the 50 mile and the 62 mile on the Orallo line. The dip steepens again north of Injune Creek, and noticeable dips are frequent as far as Baffle Creek and Westgrove, but the beds lie almost horizontal in the Dawson River near Boxvale and north of Boxvale to the Carnarvon Range. In this range they steepen very considerably, the southerly component often exceeding 6 degrees.

Of all the formations met with through the entire region, those outcropping in the Injune Creek basin show most freely the characters of an oil series, as regards nature of sediments and mode of deposition, as well as in the saline nature of this belt as compared with the other belts. It was stated by many cattle men that cattle do not require salt on the Mount Hutton (Injune Creek) runs, whereas both south and north of this belt salt is necessary. There were, however, no signs noticed either of oil exudations, or of asphalt, bitumen, earthwax, or any other result of the evaporation of the liquid fractions of oil, on which one can definitely assert this area to be an oilfield. In the records of the water bores put down by the Public Estates Improvement Branch, which kindly supplied all the particulars they could, there is frequent reference to "oily shale" having been passed through. Some of the muds out of bore 3A, which were seen by Dr. Jensen, were of a greasy nature, and floated as a dark dirty scum on top of the water; but as drilling was not in progress at the time to enable him to get an uncontaminated sample no analysis of these scums has yet been made. They are probably only carbonaceous muds. Several drillers consider that they noted a smell of kerosene in boring in various parts of the district, but such evidence is of little or no value. It would be much better if the drillers would make a practice of taking a sample of the drillings and forward them to the Mines Department for analysis, when they think they see indications of oil.

The apparent absence of earthwax, ozokerite, solid paraffin, etc., may be due to the Injune Creek beds being coal measures only in this region, but it is also quite possible that such substances will yet be found. Much of the country is covered with dense brigalow and belar scrubs. Brigalow is a timber which grows on heavy clays such as are found in association with coal seams. It probably covers most of the outcrops of coal seams, and if there were any oil or paraffin exudations in the district the odds are greatly in favour of their being hidden in brigalow scrubs. Discoveries may yet be made by the new settlers who are clearing and exploring their holdings.

If the negative evidence of the water bores on the Mount Hutton settlement be not considered to rule out the probability of oil in this district, boring for oil should be located east of the 49 mile in the Dividing Range near the head of Eurombah Creek, this being, as far as can be gauged, the axis of the meridianal anticline. But this is 8 miles or more from the railway line. Orallo seems to be a very favourable place for oil drilling on the railway line, since not only is it on a terrace of the east-west folding, but the dips around Orallo and Cornwall show a tendency to a local dome near Orallo.

However, preliminary diamond drilling, to determine the exact locus of the anticlinal axes, where much oil drilling is intended, would be highly advisable to ensure the oil bores being placed on the best sites. This is, in fact, what Mr. Cameron recommended in Publication 247. These bores need not be deep—only deep enough to cut some easily recognized horizon. It is quite impossible to determine the exact locus of anticlines by field observations owing to the paucity of outcrops.

There are three important horizons for coal in the Walloon. The first is met with in the Upper Walloon division, outcrops in Bungeworgorai Creek near Nareeten, and is met with in the Roma bore at a depth of 700 ft. to 800 ft. The coal is inferior, and very high in ash, occurs in thin bands, and the country rocks are exceedingly friable, making very bad standing ground. The next coals occur in a considerable thickness of rocks met with at depths of from 1,800 ft. to 2,400 ft. beneath Roma. They are Middle Walloon, and outcrop at Orallo, Cornwall, and Alcurah. The coals are high in ash, contain frequent bands, and occur in rocks which crumble so much on exposure to air that they are the worst of standing ground. Moreover, the coal bands are very variable in thickness at comparatively short distances.

The next coal series is that of Injune Creek, which appears to be represented by the gas and possible oil series under Roma. It is Lower Walloon, and contains scores of small seams (met with in the Injune Creek bores) and some large seams. They appear to thin out and thicken in comparatively short distances as is usual with estuarine sediments. The quality of the coal is very good in some of the seams, and the country rock in this division forms far better standing ground than in the higher measures.

The most easily accessible, and apparently also the best, seam so far located is one occurring in Boyd's and Ferguson's wells west of the railway line between the 56 and 59 mile and in other wells and water bores east of the railway, which seem to indicate an extent of at least 3 miles by 3 miles. There is, according to Mr. Boyd, 3 ft. of clean coal in his well underlain by 6 in. shale and between 6 in. and 1 ft. of coal below. The analysis of this coal from Ferguson's well yielded moisture 5%, volatile matter 40·5%, fixed carbon 49·7%, and ash 4·8%. The depth of the coal ranges from 40 ft. to 100 ft. below the surface in the area mentioned, and the thickness is generally mentioned as about 4 ft.

The Walloon area appears to contain numerous seams of kerosene shale, little specimens of which are often said to have been found in the creeks. Dr. Jack mentions kerosene shale as occurring somewhere on Injune Creek. Dr. Jensen did not obtain any specimens there, but in Bungeworgorai Creek, near the junction with Stewart Creek, occurred a bed of oil shale, which was probably 2 ft. in thickness, but only 1 ft. of the thickness was clearly exposed above the muds and talus under the bank. This shale, analysed by the Government analyst, yielded 44·8 gallons of oil to the ton.

It is obvious, therefore, that there are both good oil and coal possibilities in the Walloon measures, but development is retarded through the fact that outcrops are so rare. Diamond-drilling alone can absolutely determine the best way to exploit the mineral resources of this region.

VANCOUVER, B.C.

April 27.

Mining in the Yukon.—The Yukon Gold Company has developed a 9 ft. vein in its No. 9 tunnel, at Keno Hill, in the Mayo district. Two feet in the centre of the vein is solid galena, running upwards of 200 oz. per ton in silver, while the ore on either side is carbonate, also rich in silver. A winze has been sunk 75 ft., and a rise put up to the surface, also 75 ft., without any appreciable alteration in either the character or tenor of the vein. The company has more than 2,500 tons of ore sacked and delivered at Mayo Landing, awaiting the opening of navigation. The ore will average 200 oz. per ton in silver and between 60 and 70% in lead.

A wealthy United States syndicate, headed by F. W. Bradley, of the Bunker Hill & Sullivan, has bonded a number of claims in the Mayo district. A number of claims have

been bonded, too, by other United States syndicates. There will be much activity in the district during the coming summer.

A start is being made in placer-gold mining, and the operations will be more extensive this year than for any year since the commencement of the war. The Yukon Gold Company will open its 70 mile ditch, and by the aid of syphons and flumes will carry water to its Gold Hill diggings, above the town of Grand Forks, on Bonanza Creek, where extensive hydraulicking will be done. The company, too, will operate a dredge on Gold Run Creek. The Canadian Klondike Company will have three large dredges in operation, and the North-West Corporation two smaller dredges. These two companies will be under one management.

Consolidated Mining and Smelting.—The annual report of the Consolidated Mining & Smelting Company of Canada, Ltd., shows the mines and plant of the company to be in excellent physical condition, though, of course, like practically all other concerns of a similar nature, the company has an enormous supply of metals on hand. The report shows that during the year ended December 31, 1920, the quantity of ore treated amounted to 592,762 tons, and the following quantities of metals were produced : 42,636 oz. of gold, 1,097,930 oz. of silver, 23,474,652 lb. of lead, 4,501,594 lb. of copper, and 36,995,394 lb. of zinc. Considerable improvements were made in the method of dressing the Sullivan mine ore, resulting in more easily treatable lead and zinc concentrates, and, consequently, in increased recovery of metals and in reduction of cost of extraction. Owing to labour troubles the Rossland mines were closed for part of the year, and consequently the gold and copper output was less than it otherwise would have been. The copper smelter and refinery was worked intermittently, and, as a result, the costs in that department were greater than usual. Most of the tonnage for the lead plant was provided by the Sullivan mine in the form of crude ore, concentrate, and lead sulphate residue from the zinc plant. Considerable improvement was made in the electrolytic zinc plant, with the result that in the month of December the output was brought up to 5,000,000 lb. for the month, by far the greatest monthly output that the plant has ever made.

Some important new discoveries were made by development work at the Sullivan mine. An extension of the workings on the No. 11 level has opened up a large body of ore running high in zinc with a fair average lead content. Diamond-drilling from the bottom level has proved the continuity of the rich ore that was so profitable in the upper workings. During the year the mine produced 242,294 tons of zinc-lead ore, 13,214 tons of lead ore that was sent direct to the lead furnace without preliminary treatment, and sufficient iron pyrites to supply the needs of the sulphuric acid plant. The Rossland mines produced 50,841 tons of smelting ore and 3,683 tons of concentrate. A 2,500 ton concentrator had been designed for the treatment of the low-grade ore from these mines, and it had been the intention to erect the plant during the year, but labour troubles at the mines made it advisable not to go on with the work.

During the first three months of the present year 101,898 tons of ore has been received at the Trail smelter, compared with 73,236 tons for the corresponding period of last year. There is this difference, however, that while a large proportion of the receipts for the first quarter of last year was from independent mines, 98% of the receipts during the first three months of the present year was from the company's own mines. The Consolidated is still carrying a large surplus of metals, but it is said to be finding an outlet for its zinc in the Orient. The company has a considerable advantage in this trade, as the C.P.R. boats ply between Vancouver and the Orient, and consequently the freight charges are all in the family, so to speak.

Granby Consolidated.—After an inspection of the Granby Consolidated Mining, Smelting, & Power Company's properties, H. S. Munro, general manager, announced that the Grand Forks property has been completely closed, and all detachable machinery had been removed to the company's other properties or had been sold. The Hidden Creek mines and Anyox smelter are being operated nearer to capacity than any other copper concern in North America. A large Dorr thickener is being installed at the coal-washing plant at the Cassidy colliery, and a powerful fan is being added to the colliery equipment. Mr. Munro stated that the colliery investment was not paying 5% and the company would gladly lease or sell it at a reasonable figure. The coal does not produce a satisfactory metallurgical coke.

Other Mines in Kootenay.—Outside of the Consolidated Company's mines, there is little activity in the Kootenay district ; as

soon as one mine starts operations, another one seems to close. The difficulty of having no outlet for the ores is too heavy a burden for the majority of operators. The Silversmith mine, which ceased production last fall, but which has kept about forty men at development work throughout the winter, closed at the beginning of April. On the other hand, the Standard, at Silverton, recently sent two cars, and the Whitewater, at Retallack, one car of ore to the Bunker Hill & Sullivan smelter at Kellogg. In both instances the ore was shipped by lessees. Lessees at the Florence mine, at Ainsworth, have some 700 tons of ore on the stock piles, awaiting the time when the Trail smelter is again in the market for custom ore. It is not of high grade, and will not stand freight charges to Kellogg unless the owners of the Florence carry out their idea of putting a steamer and barges on the lakes for the purpose. The Rambler-Cariboo Mines, Ltd., issued its annual report recently, which showed a balance of $10,157, after paying $25,000 for the Jennie claim, acquired last year. Labour troubles and water shortage prevented the mine being worked for more than half of the year. Some 4,000 tons of ore was milled, and 250 tons of zinc and 220 tons of lead concentrate produced.

Premier Mine.—Mild weather has again spoiled the sledding between the Premier mine and Stewart, in the Portland Canal division. It is doubtful, at this time of the year, whether there will be sufficient frost to put the road in condition again this season. Taken as a whole, the season has been a fair one, but the weather uncertainties have clearly demonstrated the impossibility of a big mine relying on snow and frost in north-west British Columbia as the only means by which its ore can be sent to the market. By the time what is now at the wharf is shipped close to 3,000 tons of ore will have been sent to the Tacoma smelter this winter. The value of the ore shipped runs between three and four hundred dollars per ton. Good progress is being made in clearing the right-of-way for the aerial tramway. It is expected that the concentrator and cyanide plant will be in operation by midsummer. The Algunican Development Company, a Belgian concern, which next to the Premier Gold Mining Company was the biggest employer of labour in the district last year, seems to be in financial difficulties. The men it left to develop the Spider group, which it held under option, are suing for back wages totalling $4000.

Alluvial Gold.—With cost of labour and supplies reduced, it is probable that there will be a revival of gold mining in the Province this year; in fact, the returns for the first three months of the year at the Government assay office, in Vancouver, which are 55% greater than for the same period of last year, show that even as early as this in the season there is considerable activity. The fact is, of course, that there is a great deal of unemployment and no immediate likelihood of the coppper mines that have been closed re-opening; consequently many miners, rather than remain idle, have gone to the gold diggings, and already some interesting fresh discoveries have been made, which goes to show that there is money to be made from the old Cariboo gravels yet. Two men won $400 worth of nuggets in a few days near Spence's Bridle, on the North Thompson River, and then sold the claims for $12,000. The heaviest nugget weighed more than an ounce. The fact that a number of claims and mines have been bonded and substantial deposits paid, seems to augur activity in lode-gold mining also. The Independent and the Pioneer, both in Lillooet division, have changed hands recently, and the Nugget, at Sheep Creek, is being re-opened.

Platinum.—George Clothier, resident mining engineer for the No. 1 district, reports the discovery of platinum associated with bornite and chalcopyrite in veinlets in diorite at Morsby Island, one of the Queen Charlotte group. Whether the discovery is of more than scientific interest is not yet known.

Fluor-spar.—The Consolidated M. & S. Co. has closed its Rock Candy fluor-spar mine, the demand for the concentrate produced having ceased. Most of the product of the mine was sold to steel companies at Garry, Indiana. The company also used the fluor-spar for making hydrofluosilicic acid.

Oil-drilling.—The Hon. T. D. Pataullo, Minister of Lands, has announced that the Government has let a contract for a 2,000 ft. bore-hole at the south fork of the Red River, 20 miles north-west of Hudson Hope, in the Peace River region, to Lynch Brothers, of Seattle. The bore is to be sunk at the suggestion of Professor John A. Dresser, of Montreal, who made a reconnaissance survey of the oil possibilities of the district last summer for the Provincial Government. Oil seepages have been reported from Burns Lake on the Grand Trunk Pacific, and arrangements have been made to explore the dis covery with a drill.

TORONTO

PORCUPINE.—With labour and electric power sufficient for all requirements the spring has witnessed a great increase in mining activity. The Hollinger Consolidated is working to full capacity, treating about 3,300 tons of ore every 24 hours, with a force of 1,450 men. Underground development is proceeding at the rate of about a mile per month, and the output for the current year is likely to approximate $10,000,000. In order to provide against shortage of power in the future, the Company has applied to the Ontario Government for the privilege of developing electric power at Kettle Falls, on Abitibi River, some 60 miles from the mine, which is capable of generating 35,000 h.p. The application is likely to be granted, subject to a reservation of 10,000 h.p. should it be needed for public utilities.

At the Dome Mines the new ore-body encountered on the eighth and tenth levels has been driven on for 400 ft., and proved to be from 18 to 20 ft. in width, carrying an average gold content of $25 to the ton. The extent and richness of this deposit has changed the character of the mine, which has hitherto been regarded as a low-grade proposition. The mill was designed for the treatment of low-grade ore, and the treatment of the high-grade ore now being developed will involve some alterations in the milling equipment and practice.

The McIntyre has placed orders for the machinery required to double the present capacity of its mill, which is 600 tons per day. It is to be delivered and installed before December 1. Diamond-drilling has indicated the extension of the vein system of the Hollinger on the McIntyre property below the 1,000 ft. level.

The Bewick-Moreing holdings in a central position have been taken over by the Goldale Mining Co. The Tommy Burns, some ten miles south-east of the producing area, has been placed under option, and will be explored by diamond-drilling. The Ankerite Extension, not far from the Dome, has changed hands, and will be subjected to exploration. The Northern Canada Power Co., in order to prevent a power shortage in the winter season, is constructing a conservation dam at Kemoganissee Lake, on the Mattagami River, which, it is estimated, will give a minimum extra supply of 1,500 h.p.

KIRKLAND LAKE.—Work is being speeded up in the gold mines of this camp. The supply of power has been increased from 2,000 to 4,500 h.p., and the demand is increasing so rapidly that further additions to the equipment are likely to be needed shortly. The Kirkland Lake Proprietary (1919), in which British capital is largely interested, which is a merger of the Tough-Oakes, Sylvanite, and Burnside in the Kirkland Lake field and the Aladdin Cobalt, has resumed work on the Tough-Oakes and Burnside, which are being unwatered preparatory to an examination by S. C. Thomson, of New York, who has been appointed consulting engineer. The new mill of the Wright-Hargreaves, with a capacity of about 160 tons, has been put in operation, and is treating about 125 tons daily. A force of 85 men has been engaged. The mill of the Lake Shore during March treated 1910 tons of ore with a yield of $21,675. Important results have followed development on the 600 ft. level. No. 1 vein was cut having a width of 12 ft., the ore showing higher mineralization than on the upper levels. More recently vein No. 2 was cut on the same level, carrying ore stated to be very rich. A stope opened up on the 400 ft. level contains 18,702 tons of ore, averaging upwards of $28 to the ton. The Kirkland Lake is carrying on diamond-drilling from the 900 ft. level to determine the geology at depth. An important feature in connexion with recent development is that the ore-bodies at the lower levels are found to extend to greater lengths than in the upper workings. New York interests have secured control of the Minaker-Kirkland, adjoining the Lake Shore. Some 200 ft. of driving has been done at the 165 ft. level, with encouraging results. The Ontario-Kirkland is excavating a site for its mill, which will have a capacity of 100 tons per day. A substantial quantity of ore running from $15 to $20 gold to the ton has been blocked out.

COBALT.—Silver production is gradually increasing, though the low price of silver has a discouraging effect and many properties remain closed. The Nipissing during April mined ore of an estimated value of $142,610, and shipped bullion valued at $177,762. The annual report for 1920 showed net profits of $1,279,091, which was only about half of those of the two preceding years. The surplus was $3,817,043. The production of silver was 3,332,303 oz., the cost of production being 37·4 cents per oz. The ore reserves had decreased from 6,354,000 oz. to

3,568,000. President E. P. Earle stated that explorations had been lacking in results, and that shareholders must realize that they had run into lean years. The Mining Corporation of Canada has remodelled its reduction plant, giving it a capacity of 300 tons of ore daily, as compared with the former rate of 200 tons. A small force of men has been put to work on the Buffalo property, and preparations are being made for a general resumption of activity. Active development has been started at the Silver Leaf, adjoining the Crown Reserve. At the Bailey a promising vein has been encountered in a rise from the fifth level, the silver content being stated to run 1,200 oz. to the ton.

Gowganda.—There is some revival of activity in this area, where very little work was done during the winter. The main shaft on the Castle property of the Trethewey, now down 180 ft., will be sunk to the 300 ft. level, as the high-grade veins on the 165 ft. level are continuing downwards. The Miller-Lake O'Brien, which was forced to curtail production owing to power shortage, is now in full operation, working three shifts. Several properties have been re-opened, including the Saunderson, Gowganda Enterprise, McAlpine, and Powerful, and others are preparing to resume activity.

Boston Creek.—Mining is practically at a standstill in this area. The Miller Independence, the only important company in operation, closed down last month for want of funds, after carrying on energetic work for months endeavouring to locate the downward extension of a rich vein on the 500 ft. level. The directors have authorized an issue of bonds to the amount of $50,000 to finance further development.

LETTERS TO THE EDITOR

The Camborne War Memorial

The Editor :

Sir—We venture to encroach on your columns for the purpose of aiding a good cause, namely, the establishment of a War Memorial to fallen Camborne Students. Old students are scattered to the ends of the earth, and are difficult to reach for that reason. By the medium of the Magazine we hope to be able to get into contact with them.

The Committee desire to raise at least £1,000, towards which about £200 has been subscribed to date. It is proposed to purchase the old ground on which so many of these men played in days gone by, and to equip it in a manner fitting to their memory ; in addition some form of memorial tablet is to be erected in a suitable place.

An early response is desirable, as a chance of securing the ground has presented itself which may not occur again.

The cause is a good one, and our appeal is not only to all old students but to the many other good friends of Camborne Mining School.

H. W. Hutchin.
Stanley B. White.
Honorary Secretaries.

The Mining School,
Camborne, *May* 25.

Wave-transmission Rock-drill

The Editor :

Sir—Reading the letter of Mr. R. de H. St. Stephens in your issue of May, an impartial observer trying to arrive at a correct conclusion as to the respective advantages of the old and new methods is struck by the unfair obstacles raised by Mr. St. Stephens against the wave-transmission system. He assumes certain definite conditions common to both systems and enumerates the necessary plant in each case. May I point out that a mine about to be equipped would not generate current at a voltage greater than that permissible for use at the motors, as the expense of high-tension switchgear at surface and underground, and transformer underground, could not possibly be justified except where the current was generated at a central station and distributed over large areas.

Then, in calculating the overall efficiency of the wave-power, while Mr. St. Stephens is extremely generous in allowing 93% efficiency for the generator, he deducts 5% for line drop in shaft cables. This is quite impossible, as a conductor in which 5% drop occurred in 1,000 ft. could not carry the current without overheating. 1½% would be the most economical figure.

As I have shown above, the 2% transformer loss is eliminated and the 5% cable loss is now reduced to 1½%. The figure 779·25 h.p. available at motor terminals now becomes 825, and drilling capacity becomes 343 ft. per minute. On Mr. St. Stephens' figures this still leaves an advantage with compressed air of 464 to 343.

But in a practical application of wave-power to a mine it is inconceivable that a separate motor and generator would be used for each drill, and with increasing

capacity of wave generators it naturally follows that the efficiency will increase.

The most bigoted advocate of compressed air would hardly maintain that a 12 h.p. air-compressor would supply 5·8 cubic feet of air compressed to 80 lb. per sq. in. per horsepower. In effect Mr. St. Stephens is comparing a compressed-air plant of 1,000 i.h.p. with a wave-power plant of 12 h.p. This to the mind of one who has no axe to grind, but who, in common with a vast body of mining men, is anxious to determine the true facts of the case, is manifestly unfair.

A practical demonstration of the two methods on the same rock face, with carefully recorded figures by independent observers, appears to be the only true comparison.

Would either party undertake the ordeal?

CHAS. R. LOVE.

Lanner, Redruth, May 18.

PERSONAL

R. F. ALLEN has returned from Senegal.

C. V. ANTHONY has been elected a director of Henry Bath & Son, Ltd.

G. W. CAMPION is here from West Africa.

THOMAS P. CARR has been appointed manager for the Compania Minera Anglo-Hispana Matallana, Leon, Spain.

E. H. CLIFFORD, one of the consulting engineers of the Central Mining-Rand Mines group, is in London.

W. A. DOMAN has been appointed with W. LANG joint editor of the *Financial News*. Mr. DOMAN is well-known among mining men as a sound and conscientious journalist.

C. J. EMERY is here from Broken Hill.

J. W. FINCH has been visiting the Rand and the Congo, and is back again in New York.

COLIN G. FINK, lately director of the research laboratory of the Chile Exploration Co., has opened an office at South Yonkers, New York, as consulting metallurgical engineer.

A. W. HOOKE has completed his engagement with the Bisichi and Forum companies, Nigeria, and is now staying at Tunbridge Wells.

C. J. INDER, of Inder, Henderson, & Dixon, has left for Colombia.

J. W. KIRKLAND is acting as president of the South African Institute of Engineers, in the absence of James Whitehouse.

DOUGLAS LAY has been appointed manager of the Le Roi No. 2 Mine, Rossland, B.C.

WALDEMAR LINDGREN, professor of mining geology in the Massachusetts Institute of Technology, is visiting Bolivia.

E. P. MATHEWSON left on his return to the United States on May 25.

A. W. NEWBERRY has returned to New York from Nicaragua.

J. M. NIALL, chairman of the Mount Morgan Gold Mining Co., is here from Australia.

DR. ERNEST FOX NICHOLLS has been appointed president of the Massachusetts Institute of Technology.

WALTER R. SKINNER, the editor of the *Mining Manual*, celebrated his seventieth birthday last month.

ACHESON SMITH has been elected president of the American Electro-Chemical Society.

DR. A. W. STICKNEY is back from Spain and Algeria, and has gone to the United States on a short visit.

W. E. THORNE has returned from the United States.

L. VAUGHAN has opened an office at Kroh, Upper Perak, and is in control of the work at the Betong group of mines in Lower Siam.

A. J. WALTON, manager of Crown Mines, is here from Johannesburg.

JAMES WHITEHOUSE is here from the Rand.

W. B. WORTHINGTON has been elected president of the Institution of Civil Engineers.

CHARLES WILL WRIGHT passed through London last month on his way from Italy to the United States.

The following have been appointed by the Secretary for Mines to serve on the Advisory Committee for the Metalliferous Mining Industry. Mining Engineers: THOMAS FALCON, F. H. HATCH, FRANK MERRICKS. Metallurgist: F. W. HARBORD. Economic Geologists: T. C. F. HALL, HENRY LOUIS, MALCOLM MACLAREN. Representatives of Tin Mines: R. ARTHUR THOMAS, JOSEPH HARRIS. Representatives of Lead and Zinc Mines: ANTHONY WILSON, JAMES WIGNALL.

GEORGE BLAKE WALKER, a well-known Yorkshire mining engineer, died on June 1. He was at one time a partner in the firm of Bainbridge, Seymour & Co. A year or two ago he served as President of the Institution of Mining Engineers.

AMBROSE MONELL, who was for fifteen years president of the International Nickel Company, died on May 2. He graduated from Columbia University in 1896, and his first appointment was with the Carnegie Steel Company. His name is associated with the natural copper-nickel alloy now in commercial use under the name of monel metal.

TRADE PARAGRAPHS

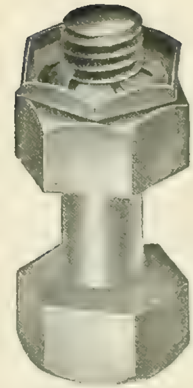
METROPOLITAN-VICKERS ELECTRICAL CO., LTD., of Manchester, send us their pamphlet No. 7875/2 describing electro-motors suitable for driving looms used in textile mills.

THE DENVER ROCK DRILL MANUFACTURING CO., of Denver, Colorado, send us a pamphlet describing the "Waughoist", a portable hoist driven by compressed air, particularly adapted for use in development operations underground.

THE WESTINGHOUSE ELECTRIC INTERNATIONAL COMPANY, of New York, send us their monthly magazine for May. This gives interesting information relating to trade in Japan, Buenos Aires, and Chile, and publishes articles on electric fans and on electric substations in France.

THE BRITISH ROPEWAY ENGINEERING CO., LTD., of 34, Fenchurch Street, London, E.C. 3, have obtained an interim injunction against Stavers & Partners, whereby the latter undertake not to carry on the business of erecting or supplying crane cables and ropeways and aerial transporters, and not to use in connexion with their business the name of "Bleichert" or "Bleichert's System" or in any way to represent that they are carrying on the business formerly carried on by Bleichert & Company.

THE PALNUT SAFETY LOCK WASHER.



THE PALNUT IN PLACE.

THE SULLIVAN MACHINERY COMPANY, of Chigaco, and Salisbury House, London, E.C. 2, send us three new pamphlets. No. 77A describes the firm's portable mine-car electrically driven air-compressors. No. 77B gives particulars of the angle-compound power-driven air-compressors; belted WJ 3, WI 3, WJ 4, direct-connected WN 3, WN 4. No. 72E describes the company's drill-sharpeners for hammer-forging drill-bits and shanks.

THE PALNUT CO., LTD., of 6 Great St. Helens, London, E.C. 3, are putting on the market a new safety lock washer, called the "Palnut". This washer is placed on top of the nut, not under it. Pressures can thus be varied at will, and the washer is easily detached when desired. The flanges are cut to fit in the base of the pitch of the thread. Being in contact with the core, they resist pressure from the nut face, with the result that the whole hexagon tends to flatten out, thus preventing the nut becoming unseated or lost. The thread of the bolt is in no may stripped or burred, and two threads of the bolt suffice for the action of the washer. The washer is particularly adapted to mining machinery, where there is much vibration. The accompanying illustrations show the washer and its position on the bolt. The price is low; for instance, the washer for an inch bolt is sold at thirty-seven shillings per gross.

THE CONSOLIDATED PNEUMATIC TOOL CO., LTD., of 170, Piccadilly, London, W. 1, have opened a branch office at 8, Clive Street, Calcutta, under the management of Captain E. Grigg, where a stock of air compressors, oil engines, and portable tools, both pneumatic and electric, together with all necessary spare parts and accessories, are kept to enable customers' requirements to be immediately filled. Full particulars as to the erection and operation of this company's well-known Giant Semi-Diesel Oil Engines can also be obtained from Captain Grigg. G. & A. Angus, of Rangoon, and the United Engineers Ltd., of Singapore, have been appointed agents for Burma and the East Indies respectively, and they will carry stocks of the labour-saving appliances manufactured by the Consolidated Pneumatic Tool Co., Ltd., so that inquiries and orders in these areas will receive immediate and prompt attention.

THE INGERSOLL-RAND CO., London office, 165, Queen Victoria Street, London, E.C. 4, send us the following information relating to a record made by No. 18 Ingersoll-Leyner drills: Some time ago a remarkable record was made by a miner by the name of Ellitson, at the Geduld mine, with No. 18 Ingersoll-Leyner drills. The Union Corporation now announce that this same miner broke his previous world's record with the same three machines in the same grade of rock and the same stoping width. The record which he has just made during the month of April is as follows: Type of drill, No. 18 Ingersoll-Leyner drills; number of drills, 3; total machine shifts, 78; total fathoms broken, 221; fathoms per machine shift, 2·83; tons broken per machine shift, 45; stoping width, 63 inches. As Mr. Ellitson has used these same drills for a considerable length of time and made remarkable fathomage in four consecutive months last year, that is, August, September, October, and November, he deserves a great deal of credit for making special efforts to break his own record with these same machines. Ordinarily a man asks for new machines whenever he wishes to make a special record. This figure of 2·83 fathoms per machine shift is an excellent performance, and is believed to stand unequalled in the world to-day under the same conditions, and not using more than three drills.

METAL MARKETS

COPPER.—The standard copper market in London during May exhibited a steadily rising tendency till towards the end of the month, when a rather easier tone manifested itself. At the beginning of May an attempt was apparently made by certain American interests to squeeze the standard market, and heavy purchases of near metal caused the market to assume a rather artificial aspect, and a backwardation made its appearance. About the middle of the month, however, the squeeze was abandoned, although some American influence was still manifestly at work supporting values, and later on the backwardation (premium commanded by cash over three months) dwindled considerably. In the meantime the American market began to firm up, and from 12¾ cents the price rose to 13¼ cents per lb. The rise in the United States was attributed to a healthier export demand, chiefly from Germany and Japan, but domestic consumption in the United States was disappointing. The artificial condition of the standard market during the month was well illustrated by the fact that not only was electrolytic at one time practically saleable as standard, but

DAILY LONDON METAL PRICES: OFFICIAL CLOSING
Copper, Lead, Zinc, and Tin per Long Ton.

COPPER.

	Standard Cash	Standard (3 mos.)	Electrolytic	Wire Bars	Best Selected
	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.
May					
9	72 5 0 to 72 10 0	71 5 0 to 71 10 0	73 0 0 to 74 0 0	73 0 0 to 74 0 0	72 10 0 to 74 10 0
10	72 0 0 to 72 5 0	71 0 0 to 71 2 6	73 0 0 to 74 0 0	73 0 0 to 74 0 0	72 10 0 to 74 10 0
11	72 0 0 to 72 2 6	71 5 0 to 71 7 6	73 10 0 to 74 10 0	73 10 0 to 74 10 0	72 10 0 to 74 10 0
12	72 12 6 to 72 15 0	71 15 0 to 71 17 6	73 10 0 to 74 10 0	73 10 0 to 74 10 0	72 10 0 to 74 10 0
13	73 2 6 to 73 5 0	72 2 6 to 72 5 0	74 0 0 to 75 0 0	74 0 0 to 75 0 0	72 10 0 to 74 10 0
17	74 2 6 to 74 5 0	73 7 6 to 73 10 0	74 10 0 to 75 10 0	74 10 0 to 75 10 0	74 0 0 to 76 0 0
18	74 10 0 to 74 15 0	73 15 0 to 74 0 0	75 0 0 to 76 0 0	75 0 0 to 76 0 0	74 0 0 to 76 0 0
19	74 17 6 to 75 0 0	74 7 6 to 74 10 0	75 0 0 to 76 0 0	75 0 0 to 76 0 0	74 0 0 to 76 0 0
20	75 5 0 to 75 7 6	75 0 0 to 75 2 6	76 0 0 to 77 0 0	76 0 0 to 77 0 0	74 10 0 to 76 0 0
23	75 10 0 to 75 12 6	75 5 0 to 75 10 0	76 0 0 to 77 0 0	76 0 0 to 77 0 0	74 10 0 to 76 0 0
24	74 0 0 to 74 2 6	74 0 0 to 74 2 6	76 0 0 to 77 0 0	76 0 0 to 77 0 0	74 0 0 to 75 10 0
25	74 15 0 to 74 17 6	74 10 0 to 74 12 6	76 0 0 to 77 0 0	76 0 0 to 77 0 0	74 0 0 to 75 10 0
26	74 10 0 to 74 12 6	74 10 0 to 74 12 6	76 0 0 to 77 0 0	76 0 0 to 77 0 0	74 0 0 to 75 10 0
27	73 17 6 to 74 0 0	73 17 6 to 74 0 0	76 0 0 to 77 0 0	76 0 0 to 77 0 0	73 10 0 to 75 0 0
30	73 0 0 to 73 5 0	73 0 0 to 73 5 0	76 0 0 to 77 0 0	76 0 0 to 77 0 0	73 10 0 to 75 0 0
31	72 10 0 to 72 15 0	72 15 0 to 72 17 6	76 0 0 to 77 0 0	76 0 0 to 77 0 0	73 0 0 to 75 0 0
June					
1	73 0 0 to 73 2 6	73 5 0 to 73 7 6	76 0 0 to 77 0 0	76 0 0 to 77 0 0	73 0 0 to 75 0 0
2	73 2 6 to 73 5 0	73 12 6 to 73 15 0	76 10 0 to 77 0 0	76 10 0 to 77 0 0	73 0 0 to 75 0 0
3	72 12 6 to 72 15 0	73 2 6 to 73 5 0	76 0 0 to 77 0 0	76 0 0 to 77 0 0	72 10 0 to 74 0 0
6	72 15 0 to 72 17 6	73 2 6 to 73 5 0	76 0 0 to 78 0 0	76 0 0 to 78 0 0	72 10 0 to 74 0 0
7	72 15 0 to 73 0 0	73 5 0 to 73 7 6	76 0 0 to 78 0 0	76 0 0 to 78 0 0	73 0 0 to 75 0 0
8	72 17 6 to 73 2 6	73 2 6 to 73 7 6	76 0 0 to 78 0 0	76 0 0 to 78 0 0	73 0 0 to 75 0 0

best select was nominally quoted below standard. The April imports into the United Kingdom were 11,413 tons against 9,889 tons in April last year.

Average price of cash standard copper: May, 1921, £73 5s. 10d.; April, 1921, £69 8s. 11d.; May, 1920, £96 18s. 1d.; April, 1920, £103 2s. 11d

TIN.—The standard tin market in London fluctuated to some extent during the past month, but on the whole the tendency was firmer. Quite a feature was the freer market in the Straits, where fair quantities have been sold at prices not greatly above the London parity. With the coal strike in progress, domestic consumption was even less than had previously been the case, and it can only be concluded that most of the interest taken recently in the metal on 'Change has been of a professional character. In the East fair quantities were sold almost daily, and shipments from the Straits during May showed a fair increase over the April figures. The premium commanded by Straits metal on the London market has diminished considerably. It is understood that the F.M.S. Government has renewed its agreement with the Dutch holders in Batavia to hold the accumulated stocks for a further three months. In America the price has been firm during the month. Owing to the coal strike, production was practically suspended at the English tin smelters during the month. The United Kingdom imports of tin in April were 317 tons, against 1,440 tons last year. America has only bought spasmodically, and apparently consumers there are not doing much. The Continent shows a fair amount of buying interest. Generally speaking, consuming interest is small and supplies ample,. but the stocks are all well held.

Average price of cash standard tin: May, 1921, £177 10s. 8d.; April, 1921, £164 0s. 11d.; May, 1920, £295 3s. 7d.; April, 1920, £345 13s. 1d.

LEAD.—The London lead market during May was fairly firm, and values rose appreciably till towards the end of the month, when an easier feeling set in. The firmness was caused to some extent by the small arrivals of metal owing to vessels holding off from English ports on account of coaling difficulties. The rise in values caused some consumers to buy small quantities, but others, finding their operations curtailed by the coal stoppage, actually featured as sellers. Consuming demand, on the whole, was, in the circumstances, fair. Spain continued to be the sole supplier of virgin lead, the United States, Mexico, Australia, and Burma sending nothing. As regards America, that country herself has been buying heavily from Spain, apparently in anticipation of the increased import tax which it is expected may be imposed shortly. The position in Spain is still obscure, and the extent of the stocks there is unknown. It appears quite possible that the higher price which is now obtainable may stimulate production once more, and in this connexion it is interesting to observe that the Mexican lead-producing industry is showing signs of greater animation.

Average price of soft pig lead: May, 1921, £23 7s. 3d.; April, 1921, £20 16s. 10d.; May, 1920, £39 3s. 2d.; April, 1920, £40 4s.

SPELTER.—The month of May saw considerable firmness in the London spelter market, and prices rose somewhat. This, of course, was chiefly due to the paucity of new supplies, which more than counterbalanced the extreme poorness of demand. With the galvanizing trade in a very depressed condition, which was further accentuated by the coal stoppage, very little consuming buying could be expected, but, nevertheless, a steady, though small, consuming inquiry trickled in. As regards supplies, Germany was unable to send anything owing to the prohibitive 50% import duty imposed by the Allies, and furthermore the insurrection in Upper Silesia would have in any case hindered the output of the zinc industry there. Belgium has been offering a little metal rather above the London price, and her production is still decreasing, being only 4,320 tons in April, against 4,640 tons in March. Norway is also willing to sell, but at higher prices than rule here. In its annual report the Vieille Montagne Co. makes the remark that Europe is now only producing 150,000 tons of spelter yearly, instead of 650,000 tons. The output in the United States during April was approximately

PRICES ON THE LONDON METAL EXCHANGE.
Silver per Standard Ounce; Gold per Fine Ounce.

Lead: Soft Foreign	Lead: English	Zinc (Spelter)	Standard Tin: Cash	Standard Tin: 3 mos.	Silver: Cash	Silver: Forward	Gold	
£ s. d. £ s. d.	£ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	d.	d.	s. d.	May
24 0 0 to 24 0 0	25 0 0	26 0 0 to 27 5 0	176 0 0 to 176 5 0	178 0 0 to 178 0 0	35⅛	34½	103 3	9
24 0 0 to 24 0 0	25 0 0	26 0 0 to 27 5 0	173 10 0 to 173 15 0	175 15 0 to 176 0 0	35	34	103 2	10
24 7 6 to 24 0 0	25 5 0	26 5 0 to 27 5 0	178 10 0 to 178 15 0	180 5 0 to 180 10 0	34½	33¾	102 11	11
24 7 6 to 23 17 6	25 5 0	26 7 6 to 27 7 6	179 0 0 to 179 10 0	181 0 0 to 181 5 0	34½	34	103 0	12
23 5 0 to 23 5 0	24 10 0	26 10 0 to 27 10 0	178 10 0 to 178 15 0	180 7 6 to 180 10 0	34¼	33¾	102 11	13
23 12 6 to 23 10 0	24 15 0	27 0 0 to 27 17 6	181 0 0 to 181 5 0	182 15 0 to 183 0 0	33¾	33½	102 11	17
23 17 6 to 23 17 6	25 0 0	27 17 6 to 28 17 6	180 15 0 to 181 0 0	182 0 0 to 182 10 0	33¼	33⅛	102 9	18
24 12 6 to 24 10 0	25 15 0	28 0 0 to 28 15 0	181 5 0 to 181 10 0	182 5 0 to 182 10 0	33¼	32¾	102 8	19
24 10 0 to 24 10 0	25 15 0	28 5 0 to 28 15 0	183 5 0 to 183 10 0	183 15 0 to 184 0 0	33¼	32⅝	102 8	20
24 7 6 to 24 7 6	25 10 0	28 0 0 to 28 10 0	184 0 0 to 184 5 0	184 10 0 to 184 15 0	33⅞	33⅜	103 0	23
24 0 0 to 23 17 6	25 5 0	27 15 0 to 28 0 0	181 0 0 to 181 5 0	181 10 0 to 181 15 0	33⅜	33	104 1	24
24 2 6 to 23 17 6	25 5 0	28 0 0 to 28 7 6	182 0 0 to 182 5 0	182 5 0 to 182 10 0	33¼	33	103 4	25
23 12 6 to 23 12 6	25 0 0	28 0 0 to 28 7 6	180 15 0 to 181 0 0	181 12 6 to 181 15 0	33½	33⅛	104 8	26
23 0 0 to 23 0 0	24 10 0	28 0 0 to 28 5 0	177 15 0 to 178 0 0	178 10 0 to 178 15 0	33⅞	33¼	105 1	27
22 10 0 to 22 10 0	24 0 0	27 10 0 to 27 15 0	173 10 0 to 173 15 0	174 5 0 to 174 10 0	34⅛	33¾	106 1	30
22 5 0 to 22 5 0	23 15 0	27 5 0 to 27 10 0	174 0 0 to 174 5 0	175 0 0 to 175 5 0	33¾	33⅜	106 4	31
								June
22 15 0 to 22 10 0	24 0 0	27 0 0 to 27 15 0	173 0 0 to 173 5 0	173 15 0 to 174 0 0	33½	33⅛	105 9	1
22 5 0 to 22 2 6	23 15 0	27 0 0 to 27 15 0	172 10 0 to 172 15 0	173 15 0 to 174 0 0	33½	33⅛	105 5	2
22 2 6 to 22 0 0	23 10 0	26 12 6 to 27 12 6	170 5 0 to 170 10 0	171 10 0 to 171 15 0	33⅞	33⅝	106 0	3
22 5 0 to 22 2 6	23 10 0	26 0 0 to 27 0 0	168 5 0 to 168 10 0	169 15 0 to 170 0 0	34	33⅞	107 7	6
22 12 6 to 22 10 0	23 15 0	26 5 0 to 27 10 0	165 15 0 to 166 5 0	167 0 0 to 167 5 0	34⅞	34⅝	109 3	7
22 17 6 to 22 12 6	24 0 0	26 10 0 to 27 15 0	137 10 0 to 167 15 0	169 0 0 to 169 5 0	34⅞	34½	107 11	8

16,500 tons, against 45,000 tons in April last year. Stocks in America are estimated at something like 80,000 tons. The Anaconda Copper Mining Co. has reopened a portion of the Washoe smelting workings to treat silver-zinc ores, and a production of 2,000,000 lb. of zinc monthly is planned.

Average price of spelter: May, 1921, £27 6s. 7d.; April, 1921, £26 1s. 5d.; May, 1920, £46 0s. 9d.; April, 1920, £48 9s. 4d.

ZINC DUST. — The market is very quiet, and present prices are about: American, £55 per ton; English, £55; and Australian, £55.

ANTIMONY.—Prices asked by first hands for English have kept steady, ordinary brands being quoted at £37 to £40 and special brands at £38 5s. to £42. Foreign material seems easier, there being sellers at £24 10s. ex warehouse.

ARSENIC.—There is practically no demand at the moment, and Cornish white is quite nominal at £46 to £48 per ton, delivered.

BISMUTH. — The quotation is steady at 7s. 6d. per lb.

CADMIUM.—Business is dull, with sellers quoting 6s. to 6s. 3d. per lb.

ALUMINIUM.—British interests are nominally quoting £150 per ton for both home and export, but Continental metal has been offering during the month at around £110, f.o.b. Continental ports.

NICKEL.—The leading producers quote £185 delivered for home business, and £185, f.o.b., for export orders.

COBALT METAL.—The price has been weak, and metal is obtainable at 15s. to 16s. per lb.

COBALT OXIDE.—A reduction of 4s. per lb. has been made in quotations, black oxide being quoted at 12s. and grey at 13s. 6d. per lb.

PLATINUM AND PALLADIUM.—Prices keep steady. Manufactured platinum and palladium are priced at £20 per oz. Raw platinum is stated to be obtainable at £17, and raw palladium around £15.

QUICKSILVER.—The tendency of late has been slightly easier, and the current quotation is £11 to £11 5s. per bottle.

SELENIUM.—The quotation continues at 10s. 6d. to 13s. per lb.

TELLURIUM.—Sellers quote 90s. to 95s. per lb.

SULPHATE OF COPPER.—The present quotation is about £30 per ton for both home and export business.

MANGANESE ORE.—The tendency has been rather easier, and Indian grades are quoted at 1s. 2½d. to 1s. 3d. per unit, c.i.f., U.K.

TUNGSTEN ORES.—Some slight signs of a recovery have been visible in this market recently, but the present price of 65% WO_3 is quoted at about 12s. 6d. to 13s. per unit, c.i.f.

MOLYBDENITE.—Business is dull, and the price has had a downward tendency. We call the quotation 47s. 6d. to 57s. 6d. per unit, nominal.

CHROME ORES.—African and Indian grades are steady at £5 10s. to £6 per ton, c.i.f., U.K.

SILVER.—The silver market in London during May was chiefly dependent for support on India, which country bought moderately. There was some liquidation by China, however, which caused weakness about the middle of the month Spot bars opened on May 2 at 34⅞d., rose to 35⅛d. on May 7, fell to 33¼d. on the 20th, subsequently recovered to 34⅛d. on the 30th, and closed on the 31st at 33¾d.

GRAPHITE.—Madagascar, 80 to 90%, is steady at £20 to £25 per ton.

IRON AND STEEL.—Business in the iron and steel trades during the past month has been virtually at a standstill owing to the prolongation of the coal strike. As regards Cleveland pig iron, no alteration was made in the official minimum quotations, but with stocks of No. 3 foundry iron being gradually diminished, owing to the cessation of production, those who had anything to sell were asking a premium of 10s. for home trade and 15s. for export. Thus the official quotation remains at £6, which price was fixed at the beginning of April. In the finished iron and steel trades, there has really been no alteration, either in the position or in home trade quotations, but with the Continent—mainly Belgium and latterly Germany—securing good export orders, British makers have started to cut quotations for shipment. They still have a long way to go, however.

STATISTICS

PRODUCTION OF GOLD IN THE TRANSVAAL.

	Rand	Else-where	Total	Price of gold per oz.
	oz.	oz.	oz.	s. d.
April, 1920	667,926	19,053	686,979	102 6
May	[illegible]	17,490	699,041	105 0
June	[illegible]	16,758	715,957	102 6
July	718,521	17,578	[illegible]	105 0
August	[illegible]	18,479	702,083	112 6
September	[illegible]	16,687	682,173	115 0
October	[illegible]	16,653	662,472	117 6
November	618,525	15,212	633,737	117 6
December	[illegible]	14,666	632,215	115 0
Total, 1920	7,949,038	204,587	8,153,625	--
January, 1921	637,425	14,168	651,593	105 0
February	543,767	14,370	588,137	[illegible] 9
March	656,572	14,551	671,123	103 9
April	665,309	16,073	681,382	103 9

NATIVES EMPLOYED IN THE TRANSVAAL MINES.

	Gold mines	Coal mines	Diamond mines	Total
April 30, 1920	189,446	12,951	5,057	207,454
May 31	184,722	12,897	4,793	202,412
June 30	179,827	13,036	4,596	197,459
July 31	174,187	13,005	4,521	191,713
August 31	169,263	13,535	4,244	187,042
September 30	163,132	13,716	4,323	181,171
October 31	159,426	13,858	4,214	177,498
November 30	158,773	14,245	3,504	176,522
December 31	159,671	14,263	3,340	177,274
January 31, 1921	165,287	14,541	3,319	183,147
February 28	171,518	14,697	1,612	187,827
March 31	174,364	14,906	1,364	190,634
April 30	172,826	14,908	1,316	189,050

COST AND PROFIT ON THE RAND.

Compiled from official statistics published by the Transvaal Chamber of Mines.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
April, 1920	2,065,446	31 5	26 3	5 2	533,940
May	2,117,725	31 9	25 11	5 10	618,147
June	2,146,899	31 10	25 2	6 8	692,510
July	2,194,050	33 6	24 6	9 0	985,058
August	2,057,560	36 11	25 0	11 11	1,226,906
September	1,950,410	38 11	25 6	13 5	1,276,369
October	1,871,149	39 9	26 1	13 8	1,278,385
November	1,799,710	40 2	26 [illegible]	13 1	1,255,749
December	1,797,970	39 11	26 8	13 3	1,193,672
January, 1921	1,895,235	35 0	26 3	8 9	829,436
February	1,575,320	35 6	28 6	7 0	550,974
March	1,958,750	34 5	26 1	8 4	813,636

PRODUCTION OF GOLD IN RHODESIA.

	1919	1920	1921
	£	oz.	oz.
January	211,917	43,428	46,956
February	220,885	44,237	40,816
March	225,808	45,779	31,995
April	213,160	47,000	47,858
May	218,057	46,266	—
June	214,215	45,054	—
July	214,919	46,208	—
August	207,339	48,740	—
September	223,719	45,471	—
October	204,184	47,343	—
November	186,462	46,782	—
December	158,835	46,190	—
Total	2,499,498	552,498	173,625

TRANSVAAL GOLD OUTPUTS.

	March		April	
	Treated	Yield	Treated	Yield
	Tons	Oz.	Tons	Oz.
Aurora West	[illegible]	£14,595†	10,800	£14,596†
Brakpan	[illegible]	22,339	55,000	22,476
City Deep	[illegible]	36,584	80,000	£182,518*
Cons. Langlaagte	[illegible]	£62,419†	[illegible]	£65,123†
Cons. Main Reef	47,800	16,759	48,000	[illegible]
Crown Mines	187,000	51,218	192,000	[illegible]
D'rb'nRoodepoortDeep	[illegible]	8,778	26,550	[illegible]
East Rand P.M.	131,500	34,270	135,000	£186,518*
Ferreira Deep	32,000	10,290	31,800	£55,717*
Geduld	45,000	15,359	44,000	15,150
Geldenhuis Deep	46,950	12,781	49,765	£67,418*
Glynn's Lydenburg	3,277	£4,990†	3,533	£6,686‡
Goch	16,600	£20,281†	17,000	£19,937†
Government G.M. Areas	136,000	£253,290†	136,000	£287,860†
Kleinfontein	48,000	13,297	47,100	13,114
Knight Central	25,800	6,178	28,800	£37,150*
Langlaagte Estate	40,000	£62,290†	38,400	£62,270†
Luipaard's Vlei	16,000	£18,456†	20,380	£21,946†
Meyer & Charlton	14,300	£45,361†	14,000	£41,467†
Modderfontein	92,000	43,114	96,000	[illegible]
Modderfontein B	57,000	29,200	58,000	£158,368*
Modderfontein Deep	42,700	22,809	42,600	22,916
Modderfontein East	26,000	10,430	25,700	£51,285*
New Unified	10,900	£13,219†	11,300	£14,062†
Nourse	42,000	13,253	46,000	£73,959*
Primrose	31,700	£24,397†	21,500	[illegible]
Randfontein Central	120,000	£187,469†	128,500	£183,309†
Robinson	39,800	7,814	39,000	[illegible]
Robinson Deep	60,100	17,279	61,300	13,114
Roodepoort United	23,000	£22,209†	23,800	[illegible]
Rose Deep	53,300	12,871	54,500	£68,043*
Simmer & Jack	61,100	13,540	60,600	14,469
Springs	42,000	18,776	42,000	18,631
Sub Nigel	9,900	5,557	9,900	6,043
Transvaal G.M. Estates	13,945	£22,415‡	15,030	£25,583‡
Van Ryn	31,100	£47,453†	31,520	£49,063†
Van Ryn Deep	50,600	£138,977†	50,400	£140,608†
Village Deep	48,700	14,643	48,600	£76,730*
West Rand Consolidated	32,300	£48,892†	32,220	£47,947†
Witw'tersr'nd (Knights)	32,000	£47,940†	36,000	£49,820†
Witwatersrand Deep	37,665	£54,669†	35,000	14,491
Wolhuter	32,200	8,291	31,700	£41,704*

* Gold at £5 3s. 3d. per oz. † £5 3s. 9d. per oz. ‡ £5 2s. 9d. per oz.

RHODESIAN GOLD OUTPUTS.

	March		April	
	Tons	Oz.	Tons	Oz.
Cam & Motor	10,052	2,666	11,100	£11,500†
Falcon	15,406	2,937*	15,293	3,086‖
Gaika	1,204	608	3,503	1,254
Globe & Phœnix	—	—	6,083	4,744
Jumbo	1,450	441	1,399	464
London & Rhodesian	2,308	£2,792	—	£2,592
Lonely Reef	1,690	1,669	5,320	5,299
Planet-Arcturus	1,950	1,065	5,450	2,592
Rezende	2,400	1,635	5,700	2,601
Rhodesia G.M. & I.	597	215	259	234
Shamva	16,150	£14,695‡	52,350	£39,825‡
Transvaal & Rhodesian	1,700	£5,028†	1,790	£5,184†

* Also 250 tons copper. † At par. ‡ Gold at £5 per oz.
‖ Also 272 tons copper.

WEST AFRICAN GOLD OUTPUTS.

	March		April	
	Treated	Value	Treated	Value
	Tons	Oz.	Tons	Oz.
Abbontiakoon	6,709	£11,497*	6,604	£10,663*
Abosso	5,000	1,996	5,012	1,952
Akoko	—	—	—	—
Ashanti Goldfields	4,837	4,720	5,759	5,325
Obbuassi	818	£2,480†	760	£2,838†
Prestea Block A	6,705	£16,094†	5,445	£9,993*
Taquah	2,300	1,222	2,200	1,303

* At par. † Including premium.

Australian Gold Outputs.

1921	West Australia	Victoria	Queensland	New South Wales
	oz.	oz.	oz.	£
January .	51,458	4,587	4,582	20,463
February.	27,557	10,940	9,046	21,575
March ...	47,886	12,383	6,690	24,344
April	—	—	—	34,101
May	—	—	—	—
June.....	—	—	—	—
July	—	—	—	—
August...	—	—	—	—
September	—	—	—	—
October .	—	—	—	—
November	—	—	-	—
December	—	—	-	—
Total ..	126,901	27,910	20,318	100,483

West Australian Gold Statistics.—Par Values.

	Reported for Export Oz.	Delivered to Mint Oz.	Total Oz.	Total Value £
April, 1920	835	56,256	57,091	242,506
May	227	50,976	51,203	217,495
June.............	502	56,679	57,181	242,638
July	—	48,341	48,341	205,340
August...........	167	54,258	54,425	231,185
September.......	141	54,940	55,081	233,963
October	174	53,801	53,975	229,275
November	128	54,729	54,857	233,017
December	321	53,595	53,916	229,057
January, 1921	523	50,934	51,457	218,574
February	684	26,872	27,556	117,050
March............	10	47,875	47,885	203,401
April	607	46,602	47,209	200,635
May	474	47,638	51,503	217,495

Australasian Gold Outputs.

	March		April	
	Tons	Value £	Tons	Value £
Associated G.M. (W.A.)	5,977	7,961‖	5,977	6,890‖
Blackwater (N.Z.)	2,956	5,742*	2,888	5,110*
Bullfinch (W.A.)	—	—	—	—
Gold'n Horseshoe (W.A)	9,936	5,183‡	9,024	4,747‡
Grt Boulder Pro. (W.A.)	8,585	24,800‖	9,033	27,099‖
Ivanhoe (W.A.)	14,973	6,230‡	12,217	5,773‡
Kalgurli (W.A.)	4,280	9,691‖	—	—
Lake View & Star (W.A.)	7,067	14,521†	6,656	14,717†
Menzies Con. (W.A.) ..	1,350	2,145*	1,760	2,928*
Mount Boppy (N.S.W.)	5,590	1,089‡	3,696	1,045‡
Oroya Links (W.A.) ...	1,490	8,409†	1,442	9,235†
Progress (N.Z.)........	—	—	—	—
Sons of Gwalia (W.A.) .	—	—	—	—
South Kalgurli (W.A.) .	7,216	12,188‖	7,081	12,402‖
Waihi (N.Z.)..........	12,204	3,056‡ 23,304§	10,907	2,997‡ 31,134§
,, Grand Junc'n (N.Z.)	5,780	2,039‡ 8,354§	5,260	1,737‡ 5,947§
Yuanmi (W.A.)	1,200	4,342*	1,512	5,407*

* Including premium ; † Including royalties ; ‡ Oz. gold ; § Oz. silver ; ‖ At par.

Miscellaneous Gold and Silver Outputs.

	March		April	
	Tons	Value £	Tons	Value £
Brit. Plat. & Gold (C'lbia)		166§	—	326§
El Oro (Mexico)	29,500	202,000†	31,500	206,000†
Esperanza (Mexico)	–	308†‡	—	2,318†‡
Frontino & Bolivia (C'lbia)	2,450	7,624	2,270	7,997
Mexico El Oro (Mexico)..	11,340	186,960†	11,200	182,780†
Mining Corp. of Canada .	—	—	—	—
Oriental Cons. (Korea) ...	17,235	109,644†	—	97,000†
Ouro Preto (Brazil)	7,200	2,272‖	7,100	2,222‖
Plym'th Cons. (Calif'rnia	10,000	11,345	9,600	10,663
St. John del Rey (Brazil).	—	38,000	—	40,000
Santa Gertrudis (Mexico)	37,754	9,098‡	35,053	13,421‡
Tolima (Colombia)	55**	—	90**	—
Tomboy (Colorado)	15,600	59,000†	16,000	48,500†

* Oz. silver. † U.S. Dollars. ‡ Profit, gold and silver. ‖ Oz. gold. § Oz. platinum and gold. ** Production of silver ore.

Pato (Colombia) : 10 days to April 28, $26,030 from 36,055 cu. yd.; 12 days to May 10, $29,677 from 35,410 cu. yd.

Nechi (Colombia) : 43 days to April 26, $31,752 from 124,292 cu. yd. ; 16 days to May 12, $23,357 from 120,000 cu. yd.

Production of Gold in India.

	1917	1918	1919	1920	1921
	Oz.	Oz.	Oz.	Oz.	Oz.
January	44,718	41,420	38,184	39,073	34,028
February ...	42,566	40,787	36,384	38,872	32,529
March	44,617	41,719	38,317	38,760	32,576
April	43,726	41,504	38,248	37,307	32,363
May........	42,901	40,889	38,608	38,191	—
June	42,924	41,264	38,359	37,864	—
July	42,273	40,229	38,549	37,129	—
August	42,591	40,496	37,850	37,375	—
September ..	43,207	40,088	36,813	35,497	—
October	43,041	39,472	37,138	35,023	—
November ..	42,915	36,984	39,628	34,522	—
December ..	44,883	40,149	42,643	34,919	—
Total ..	520,362	485,236	461,171	444,532	131,496

Indian Gold Outputs.

	March.		April.	
	Tons Treated	Fine Ounces	Tons Treated	Fine Ounces
Balaghat	3,250	2,324	3,200	2,328
Champion Reef	11,710	4,407	11,610	4,492
Mysore..............	15,573	11,285	15,690	11,027
North Anantapur	700	908	700	901
Nundydroog	8,952	5,204	8,456	5,189
Ooregum	12,900	8,448	12,500	8,426

Base Metal Outputs.

		March	April
Arizona Copper	Short tons copper ..	1,000	1,000
British Broken Hill ...	Tons lead conc. ...	—	—
	Tons zinc conc.	—	—
	Tons carbonate ore	-	—
Broken Hill Prop......	Tons lead conc. ...	—	—
	Tons zinc conc.		—
Broken Hill South	Tons lead conc.	697	2,673
Burma Corp.	Tons refined lead ..	3,020	2,369
	Oz. refined silver ..	245,962	231,934
Hampden Cloncurry ..	Tons copper	-	—
	Oz. gold	—	—
Mount Lyell	Tons copper	512	439
	Oz. silver	15,413	11,073
	Oz. gold	389	292
Mount Morgan	Tons Copper	-	—
	Oz. gold		—
North Broken Hill.....	Tons lead	—	—
	Oz. silver	—	—
Rhodesia Broken Hill	Tons lead	1,630	1,812
Sulphide Corporation ..	Tons lead conc. ...	1,868	1,806
	Tons zinc conc	2,850	2,726
Tanganyika	Tons copper	2,488	2,189
Zinc Corporation	Tons zinc conc......	8,740	8,520
	Tons lead conc. ...	71	617

Imports of Ores, Metals, etc., into United Kingdom.

		March	April
Iron Ore	Tons	257,324	123,583
Manganese Ore	Tons	20,987	7,694
Copper and Iron Pyrites	Tons	38,166	14,662
Copper Ore, Matte, and Prec.	Tons	932	7,744
Copper Metal	Tons	12,483	11,840
Tin Concentrate	Tons	2,255	1,953
Tin Metal......................	Tons	576	317
Lead, Pig and Sheet	Tons	12,560	7,951
Zinc (Spelter)	Tons	5,803	11,401
Quicksilver	Lb.	378,750	411,316
Zinc Oxide......................	Tons	342	328
White Lead	Cwt.	4,889	4,770
Barytes, ground	Cwt.	18,588	21,133
Phosphate	Tons	25,726	28,210
Sulphur	Tons	6,435	5
Nitrate of Soda.................	Cwt.	58,079	114,249
Petroleum			
Crude	Gallons	—	7,520,101
Lamp Oil	Gallons	11,603,953	9,992,778
Motor Spirit	Gallons	23,056,848	26,191,535
Lubricating Oil	Gallons	3,844,085	3,374,996
Gas Oil	Gallons	4,282,603	3,067,510
Fuel Oil	Gallons	41,148,617	46,588,689
Total Petroleum	Gallons	83,938,899	96,738,546

OUTPUTS OF TIN MINING COMPANIES.

In Tons of Concentrate.

	Feb.	March	April
	Tons	Tons	Tons
Nigeria:			
Associated Nigerian	7	—	—
Bisichi	26	22	27
Bongwelli	—	—	—
Champion (Nigeria)	—	—	—
Dua	1½	½	—
Ex-Lands	20	20	20
Filani	5½	—	2
Gold Coast Consolidated	2	3	—
Gurum River	12	13	7
Jantar	—	—	—
Jos	15	16	6
Kaduna	14¾	—	10
Kaduna Prospectors	8½	14	11
Kano	4	3	—
Lower Bisichi	5¾	6½	4¼
Lucky Chance	—	—	—
Minna	1½	3	—
Mongu	60	53	36
Naraguta	—	70	45
Naraguta Extended	10	8	8
Nigerian Consolidated	24	20	8
N. N. Bauchi	40	45	41½
Offin River	—	—	—
Rayfield	30	28	30
Ropp	82	97	95
Rukuba	—	4½	5
South Bukeru	13	12	26
Sybu	¾	¾	1¾
Tin Fields	¼	6	4
Yarde Kerri	7	13	13
Federated Malay States:			
Chenderiang	—	81*	—
Gopeng	66	72	77½
Idris Hydraulic	21	21	21
Ipoh	15½	17½	—
Kamunting	—	122*	—
Kinta	28½	30	36
Labat	56½	57	51
Malayan Tin	80½	95½	77
Pahang	136	213	230
Rambutan	15	15	15½
Sungei Besi	35	42	34
Tekka	29	30	31
Tekka-Taiping	15	13½	11
Tronoh	19	20	22
Cornwall:			
East Pool	—	—	—
Geevor	—		—
South Crofty	—	—	—
Other Countries:			
Aramayo Francke (Bolivia)	130	200	—
Berenguela (Bolivia)	26	31	27
Briseis (Tasmania)	8	8	8
Deebook Ronpibon (Siam)	16	30½	28
Leeuwpoort (Transvaal)	—	—	—
Macreadv (Swaziland)	—	—	—
Renong (Siam)	31½	21	72
Rooiberg Minerals (Transvaal)	45	56	50
Siamese Tin (Siam)	50	57	76
Tongkah Harbour (Siam)	33	37	43
Zaaiplaats (Transvaal)	13	—	—

* Three months.

NIGERIAN TIN PRODUCTION.

In long tons of concentrate of unspecified content.

Note.—These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual outputs.

	1916	1917	1918	1919	1920	1921
	Tons	Tons	Tons	Tons	Tons	Tons
January	531	667	678	613	547	438
February	528	646	668	623	477	370
March	547	655	707	606	505	445
April	486	555	584	546	467	394
May	536	509	525	483	383	—
June	510	473	492	484	435	—
July	506	479	545	481	484	—
August	498	551	571	616	447	—
September	535	538	520	561	528	—
October	584	578	491	625	628	—
November	679	621	472	536	544	—
December	654	655	518	511	577	
Total	6,594	6,927	6,771	6,685	6,022	1,647

PRODUCTION OF TIN IN FEDERATED MALAY STATES.

Estimated at 70% of Concentrate shipped to Smelters. Long Tons.

	1917	1918	1919	1920	1921
	Tons	Tons	Tons	Tons	Tons
January	3,558	3,030	3,765	4,265	3,298
February	2,755	3,197	2,734	3,014	3,111
March	3,286	2,609	2,819	2,770	2,190
April	3,251	3,308	2,858	2,606	2,692
May	3,113	3,332	3,407	2,741	—
June	3,489	3,070	2,877	2,940	—
July	3,253	2,373	3,756	2,824	—
August	3,413	3,259	2,956	2,786	—
September	3,154	3,157	3,161	2,734	—
October	3,436	2,870	3,221	2,837	—
November	3,300	3,132	2,972	2,573	—
December	3,525	3,022	2,409	2,838	—
	39,833	37,370	36,935	34,928	11,291

STOCKS OF TIN.

Reported by A. Strauss & Co. Long Tons.

	Mar. 31	April 30	May 31
Straits and Australian Spot	1,738	1,357	1,430
Ditto, Landing and in Transit	80	185	585
Other Standard, Spot and Landing	5,456	5,081	4,457
Straits, Afloat	385	775	1,505
Australian, Afloat	200	150	150
Banca, in Holland	2,974	2,867	3,405
Ditto, Afloat	—	200	445
Billiton, Spot	579	534	644
Billiton, Afloat	—	—	30
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	95	100	475
Total Afloat for United States	781	1,441	2,595
Stock in America	3,476	2,441	2,046
Total	15,764	15,131	17,767

SHIPMENTS, IMPORTS, SUPPLY, AND CONSUMPTION OF TIN.

Reported by A. Strauss & Co. Long tons.

	Mar.	April	May
Shipments from:			
Straits to U.K.	395	775	1,425
Straits to America	395	925	1,735
Straits to Continent	125	100	507
Straits to other places	289	825	200
Australia to U.K.	50	—	—
U.K. to America	100	295	490
Imports of Bolivian Tin into Europe	366	811	353
Supply:			
Straits	915	1,800	3,667
Australian	50	—	—
Billiton	—	—	150
Banca	79	70	1,180
Standard	1,290	865	394
Total	2,334	2,735	5,391
Consumption:			
U.K. Deliveries	1,359	1,531	1,000
Dutch ,,	389	152	398
American ,,	1,683	1,590	1,225
Straits, Banca & Billiton, Continental Ports, etc.	39	95	132
Total	3,470	3,368	2,755

Outputs Reported by Oil-producing Companies.

		March	April
Anglo-Egyptian	Tons..	13,627	12,478
Anglo-United	Barrels	8,900	10,101
Apex Trinidad	Barrels	43,525	39,241
British Burmah	Barrels	65,768	66,200
Caltex	Barrels	92,820	—
Dacia Romana	Tons..	236	238
Kern River	Barrels	105,220	—
Lobitos	Tons..	8,389	8,160
Roumanian Consol	Tons..	1,375	1 849
Santa Maria	Tons..	1,286	1,400
Steaua Romana	Tons..	17,910	20,095
Trinidad Leaseholds	Tons..	13,400	15,900
United of Trinidad	Tons..	3,698	2,813

Quotations of Oil Companies' Shares.

Denomination of Shares £1 unless otherwise noted.

	May 5, 1921			June 6, 1921		
	£	s.	d.	£	s.	d.
Anglo-American	5	0	0	4	15	0
Anglo-Egyptian B	2	0	0	1	17	6
Anglo-Persian 1st Pref.	1	2	6	1	2	6
Anglo-United, Wyoming		10	0		8	9
Apex Trinidad	2	10	0	2	5	0
British Borneo (10s.)		17	6		16	3
British Burmah (8s.)	1	1	3	1	0	0
Burmah Oil	7	15	0	6	15	0
Caltex ($1)		6	6		6	3
Dacia Romano	1	0	0	1	0	0
Kern River, Cal. (10s.)	1	2	6	1	1	0
Lobitos, Peru	4	5	0	4	0	0
Mexican Eagle, Ord. ($5)	6	12	6	6	10	0
,, ,, Pref. ($5)	6	7	6	6	5	0
North Caucasian (10s.)		17	6		18	9
Phœnix, Roumania		12	6		10	6
Roumaian Consolidated		14	3		13	6
Royal Dutch (100 gulden)	52	0	0	47	0	0
Scottish American		12	6		10	0
Shell Transport, Ord.	6	2	6	5	11	3
,, ,, Pref. (£10)	8	5	0	8	10	0
Trinidad Central	4	12	6	4	5	0
Trinidad Leaseholds	2	12	6	2	12	6
United British of Trinidad	1	2	6	1	2	6
Ural Caspian	1	0	0	1	0	0
Uroz Oilfields (10s.)		8	9		9	0

Dividends Declared by Mining Companies.

Date	Company	Par Value of Shares	Amount of Dividend
May 25 ..	Burmah Oil	£1	4s. tax paid.
May 24 ..	Cassel Cyanide	5s.	4d. less tax.
May 26 ..	Central Mining and Investment	£8	6s. tax paid.
May 13 ..	Chinese Engineering & Mining	£1	10% tax paid.
June 4 ..	Cock's Pioneer	£1	1s. less tax.
May 24 ..	Great Boulder	2s.	6d. less tax.
May 11 ..	Lake View Investment Trust	10s.	5% less tax.
May 11 ..	Lonely Reef Gold	£1	15% less tax.
May 30 ..	Mexican Petroleum	Pr. $100 Or. $100	2% 3%
May 25 ..	New Heriot	£1	5s.*
May 30 ..	Pan-American Petroleum	Or.A & B $50	3%
May 18 ..	Rambutan	£1	8d. less tax.
June 4 ...	Royal Dutch	—	40%
May 26 ..	St. John del Rey	£1	1s. 3d. less tax.
June 4 ...	Shell Transport & Trading..	Or. £1	25% tax paid.

* First distribution on liquidation.

PRICES OF CHEMICALS. June 9.

These quotations are not absolute; they vary according to quantities required and contracts running.

		£	s.	d.
Acetic Acid, 40%	per cwt.	1	4	0
,, 80%	,,	2	8	0
,, Glacial	per ton	63	0	0
Alum	,,	17	0	0
Alumina, Sulphate	,,	15	10	0
Ammonia, Anhydrous	per lb.		2	6
,, 0·880 solution	per ton	32	10	0
,, Carbonate	per lb.			4
,, Chloride, grey	per ton	44	10	0
,, ,, pure	per cwt.	3	15	0
,, Nitrate	per ton	48	0	0
,, Phosphate	,,	75	0	0
,, Sulphate	,,	21	10	0
Antimony, Tartar Emetic	per lb.		2	7
,, Sulphide, Golden	,,		1	5
Arsenic, White	per ton	50	0	0
Barium Carbonate	,,	11	0	0
,, Chlorate	per lb.			11
,, Chloride	per ton	18	0	0
,, Sulphate	,,	10	0	0
Benzol, 90%	per gal.		3	0
Bisulphate of Carbon	per ton	56	0	0
Bleaching Powder, 35% Cl.	,,	18	0	0
,, Liquor, 7%	,,	7	0	0
Borax	,,	34	0	0
Boric Acid Crystals	,,	69	0	0
Calcium Chloride	,,	9	0	0
Carbolic Acid, crude 60%	per gal		1	9
,, ,, crystallized, 40	per lb.			6½
China Clay (at Runcorn)	per ton	4	0	0
Citric Acid	per lb.		2	6
Copper, Sulphate	per ton	31	0	0
Cyanide of Sodium, 100%	per lb.		1	0
Hydrofluoric Acid	,,			7½
Iodine	per oz.		1	0
Iron, Nitrate	per ton	9	0	0
,, Sulphate	,,	4	10	0
Lead, Acetate, white	,,	46	0	0
,, Nitrate	,,	48	0	0
,, Oxide, Litharge	,,	34	0	0
,, White	,,	44	0	0
Lime, Acetate, brown	,,	8	10	0
,, ,, grey 80%	,,	12	10	0
Magnesite, Calcined	,,	21	0	0
Magnesium, Chloride	,,	16	0	0
,, Sulphate	,,	10	0	0
Methylated Spirit 64° Industrial	per gal.		6	0
Nitric Acid, 80° Tw.	per ton	31	0	0
Oxalic Acid	per lb.			10½
Phosphoric Acid	per ton	50	0	0
Potassium Bichromate	per lb.			10½
,, Carbonate	per ton	45	0	0
,, Chlorate	per lb.			5
,, Chloride 80%	per ton	20	0	0
,, Hydrate (Caustic) 90%	,,	36	0	0
,, Nitrate	,,	55	0	0
,, Permanganate	per lb.		1	9
,, Prussiate, Yellow	,,		1	3
,, ,, Red	,,		2	3
,, Sulphate, 90%	per ton	20	0	0
Sodium Metal	per lb.		1	4
,, Acetate	per ton	26	0	0
,, Arsenate 45%	,,	44	0	0
,, Bicarbonate	,,	12	0	0
,, Bichromate	per lb.			7½
,, Carbonate (Soda Ash)	per ton	15	0	0
,, ,, (Crystals)	,,	7	0	0
,, Chlorate	per lb.			4½
,, Hydrate 76%	per ton	27	0	0
,, Hyposulphite	,,	17	0	0
,, Nitrate, 95%	,,	19	0	0
,, Phosphate	,,	24	0	0
,, Prussiate	per lb.			7
,, Silicate	per ton	11	15	0
,, Sulphate (Salt-cake)	,,	7	10	0
,, ,, (Glauber's Salts)	,,	6	10	0
,, Sulphide	,,	28	10	0
,, Sulphite	,,	12	10	0
Sulphur, Roll	,,	14	10	0
,, Flowers	,,	15	0	0
Sulphuric Acid, Fuming, 65%	,,	24	0	0
,, ,, free from Arsenic, 144°	,,	6	5	0
Superphosphate of Lime, 30%	,,	8	10	0
Tartaric Acid	per lb.		1	7
Turpentine	per cwt.	4	15	0
Tin Crystals	per lb.		1	5
Titanous Chloride	,,		1	0
Zinc Chloride	per ton	22	10	0
Zinc Sulphate	,,	18	0	0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS	June 5, 1920	June 6, 1921
	£ s. d.	£ s. d.
RAND:		
Brakpan	3 11 3	2 10 0
Central Mining (£8)	8 17 6	6 0 0
City & Suburban (£4)	1 5	[illegible] 0
City Deep	2 7 6	2 2 6
Consolidated Gold Fields	1 10 0	17 6
Consolidated Langlaagte	17 0	10 0
Consolidated Main Reef	11 0	10 0
Consolidated Mines Selection (10s.)	1 4 0	13 [illegible]
Crown Mines (10s.)	2 8 9	2 0 0
Daggafontein	12 0	[illegible]
Durban Roodepoort Deep	7 0	3 3
East Rand Proprietary	7 3	4 0
Ferreira Deep	8 6	7 6
Geduld	2 0 0	2 11 3
Geldenhuis Deep	5 0	4 6
Government Gold Mining Areas	1 8 9	1 0 0
Johannesburg Consolidated	1 6 0	1 3 0
Kleinfontein	7 0	5 6
Knight Central	3 9	4 0
Knights Deep	6 0	10 0
Langlaagte Estate	14 6	11 6
Meyer & Charlton	4 12 6	4 0 0
Modderfontein (10s.)	3 12 6	3 5 0
Modderfontein B (5s.)	6 7 6	1 6 3
Modderfontein Deep (5s.)	2 10 0	2 5 0
Modderfontein East	1 2 9	11 3
New State Areas	1 7 6	1 2 6
Nourse	7 6	7 0
Rand Mines (5s.)	2 14 0	2 5 0
Rand Selection Corporation	2 15 0	2 15 0
Randfontein Central	12 6	8 6
Robinson (£5)	8 0	9 0
Robinson Deep A (1s.)	18 9	10 0
Rose Deep	15 6	13 0
Simmer & Jack	3 9	2 6
Springs	2 3 9	1 16 3
Sub-Nigel	15 6	12 6
Union Corporation (12s. 6d.)	19 3	15 0
Van Ryn	16 3	10 0
Van Ryn Deep	4 8 9	3 15 0
Village Deep	10 6	7 6
West Springs	15 6	12 6
Witwatersrand (Knight's)	15 0	13 9
Witwatersrand Deep	8 6	6 0
Wolhuter	4 9	4 3
OTHER TRANSVAAL GOLD MINES:		
Glynn's Lydenburg	10 0	6 6
Sheba (5s.)	1 6	1 0
Transvaal Gold Mining Estates	10 0	7 6
DIAMONDS IN SOUTH AFRICA:		
De Beers Deferred (£2 10s.)	22 10 0	10 5 0
Jagersfontein	4 10 0	2 5 0
Premier Deferred (2s. 6d.)	12 5 0	4 15 0
RHODESIA:		
Cam & Motor	9 0	10 0
Chartered British South Africa	16 6	12 0
Falcon	9 9	5 0
Gaika	12 6	8 6
Globe & Phœnix (5s.)	14 9	16 0
Lonely Reef	3 3 9	2 2 6
Rezende	2 15 0	3 0 0
Shamva	1 16 3	1 10 0
Willoughby's (10s.)	5 0	4 6
WEST AFRICA:		
Abbontiakoon (10s.)	3 0	2 9
Abosso	12 3	8 0
Ashanti (4s.)	17 3	12 0
Prestea Block A	3 0	1 6
Taquah	15 6	8 0
WEST AUSTRALIA:		
Associated Gold Mines	3 6	3 0
Associated Northern Blocks	3 0	2 0
Bullfinch	3 6	1 0
Golden Horse Shoe (£5)	18 9	11 3
Great Boulder Proprietary (2s.)	8 3	5 6
Great Fingall (10s.)	2 0	1 6
Hampton Properties	1 0 0	5 0
Ivanhoe (£5)	1 7 6	15 0
Kalgurli	12 6	11 3
Lake View Investment (10s.)	17 0	11 0
Sons of Gwalia	6 6	5 0
South Kalgurli (10s.)	4 0	6 9

GOLD, SILVER, cont.	June 5, 1920	June 6, 1921
	£ s. d.	£ s. d.
OTHERS IN AUSTRALASIA:		
Blackwater, New Zealand	8 0	2 6
Consolidated Gold Fields of New Zealand	3 0	2 0
Mount Boppy, N.S.W. (10s.)	4 0	1 0
Progress, New Zealand	1 0	1 3
Waihi, New Zealand	1 18 9	1 10 0
Waihi Grand Junction, New Zealand	11 3	8 6
AMERICA:		
Buena Tierra, Mexico	10 0	2 6
Camp Bird, Colorado	16 0	4 0
El Oro, Mexico	12 0	10 0
Esperanza, Mexico	12 3	17 6
Frontino & Bolivia, Colombia	12 6	10 0
Le Roi No. 2 (£5), British Columbia	10 0	2 6
Mexico Mines of El Oro, Mexico	6 7 6	4 15 0
Nechi (Pref. 10s.), Colombia	8 9	6 3
Oroville Dredging, Colombia	1 3 0	1 2 6
Plymouth Consolidated, California	18 9	12 6
St. John del Rey, Brazil	17 0	15 0
Santa Gertrudis, Mexico	1 6 0	5 6
Tomboy, Colorado	10 9	5 0
RUSSIA:		
Lena Goldfields	1 0 0	10 0
Orsk Priority	10 0	10 0
INDIA:		
Balaghat (10s.)	8 9	7 0
Champion Reef (2s. 6d.)	3 0	1 6
Mysore (10s.)	16 3	12 3
North Anantapur	4 0	2 6
Nundydroog (10s.)	13 0	5 0
Ooregum (10s.)	14 3	11 3
COPPER:		
Arizona Copper (5s.), Arizona	2 6 3	1 2 6
Cape Copper (£2), Cape and India	1 2 6	15 0
Esperanza, Spain	5 9	6 3
Hampden Cloncurry, Queensland	15 0	5 0
Mason & Barry, Portugal	1 10 0	1 15 0
Messina (5s.), Transvaal	5 6	4 0
Mount Elliott (£5), Queensland	2 5 0	12 6
Mount Lyell, Tasmania	1 4 3	12 6
Mount Morgan, Queensland	1 1 3	11 3
Namaqua (£2), Cape Province	1 10 0	15 0
Rio Tinto (£5), Spain	35 10 0	31 0 0
Russo Asiatic Consd., Russia	10 6	11 6
Sissert, Russia	11 3	7 6
Spassky, Russia	1 0 0	13 9
Tanganyika, Congo and Rhodesia	1 16 3	1 5 0
LEAD-ZINC:		
BROKEN HILL:		
Amalgamated Zinc	1 6 3	16 3
British Broken Hill	2 0 0	17 6
Broken Hill Proprietary	3 3 9	1 17 6
Broken Hill Block 10 (£10)	1 3 9	10 0
Broken Hill North	2 12 6	1 5 0
Broken Hill South	2 13 9	1 5 0
Sulphide Corporation (15s.)	17 6	10 0
Zinc Corporation (10s.)	18 0	8 9
ASIA:		
Burma Corporation (10 rupees)	9 0 0	7 0†
Russian Mining	10 0	7 6
RHODESIA:		
Rhodesia Broken Hill (5s.)	11 9	7 6
TIN:		
Aramayo Francke, Bolivia	3 15 0	2 5 0
Bisichi (10s.), Nigeria	12 0	4 6
Briseis, Tasmania	4 9	2 6
Dolcoath, Cornwall	3 0	1 0
East Pool (5s.), Cornwall	10 0	3 6
Ex-Lands Nigeria (2s.), Nigeria	3 6	1 6
Geevor (10s.), Cornwall	11 3	2 6
Gopeng, Malay	1 18 9	1 11 3
Ipoh Dredging, Malay	16 3	11 3
Kamunting, Malay	2 10 0	1 7 6
Kinta, Malay	2 10 0	1 10 0
Malayan Tin Dredging, Malay	2 [illegible] 0	1 8 9
Mongu (10s.), Nigeria	17 6	12 6
Naraguta, Nigeria	11 3	18 9
N. N. Bauchi, Nigeria (10s.)	5 0	3 0
Pahang Consolidated (5s.), Malay	10 3	6 6
Rayfield, Nigeria	9 3	4 0
Renong Dredging, Siam	2 2 6	1 12 6
Ropp (4s.), Nigeria	9 9	6 6
Siamese Tin, Siam	3 10 0	2 2 6
South Crofty (5s.), Cornwall	12 0	6 6
Tehidy Minerals, Cornwall	17 6	8 9
Tekka, Malay	5 5 0	17 6*
Tekka-Taiping, Malay	1 6 3	1 0 0
Tronoh, Malay	2 1 3	1 5 0

* New Shares. † 10-rupee shares of Indian Co.

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also notices of new books and pamphlets, lists of patents on mining and metallurgical subjects, and abstracts of the yearly reports of mining companies.

THE SEARCH FOR OIL IN WESTERN CANADA

The *Bulletin* of the Canadian Institute of Mining and Metallurgy for April contains two papers on the search for oil in Western Canada, presented at the March meeting of the Institute, one by John Ness, geologist for Imperial Oil, Ltd., and the other by E. M. Kindle, a member of the Canadian Geological Survey. It should be mentioned that Imperial Oil, Ltd., is a subsidiary of the Standard Oil Company, and its chief business is oil-refining at Vancouver, Regina, Sarnia, Halifax, and Montreal. We quote that part of Mr. Ness's paper dealing with Alberta and Great Slave Lake. As we quoted Dr. Bosworth on the Mackenzie oil find last month it is not necessary to refer in detail to the part of Mr. Ness's paper on this subject, or to Mr. Kindle's paper.

The area which the Imperial Oil Company is testing extends from the plains of Saskatchewan on the east to the foot-hills of the Rockies on the west, and from the international boundary on the south to within the Arctic circle. This vast extent of territory may be conveniently divided into three groups, in which the geological features are so dissimilar that each carries its own particular problem. First, there are the Cretaceous rocks of eastern Alberta and Saskatchewan, practically undisturbed and heavily covered by glacial material. Secondly, the folded and faulted Cretaceous of the foot-hills belt, the outer folds of which give a certain amount of promise structurally. Thirdly, the Devonian of the Mackenzie Valley in which oil has recently been struck.

As regards the geology of the plains of eastern Alberta and western Saskatchewan the structure is monoclinal, although there are certain local irregularities and undulations, and evidence of two general lines of folding. The first of these, which is the continuation of the structure found in the Sweet Grass Hills of Montana, probably extends north to Bow River. The second crosses the Alberta-Saskatchewan boundary south of Macklin and trends north-west. The efforts of the Imperial Oil geologists have centred upon these known, or assumed, lines of folding or faulting which previous investigation has indicated as likely to repay attention ; but a general survey—of necessity, hurried and incomplete—has been made of the whole region as far north as Lac la Biche, south to the international boundary, east to Battleford, and west as far as the Cretaceous rocks are exposed. Most of the exposures in this vast area were visited and examined, a task entailing, in many places, more travelling than actual geological work, owing to the dearth of rock sections. Hundreds of square miles have been traversed without a single outcrop of bedrock being seen, the streams having simply cut their courses in the extremely thick glacial deposits. Nothing revolutionary was discovered during these surveys, the previous work in the area leaving little to the imagination. Attention was devoted principally to the selection of suitable locations for testing the oil possibilities, those areas where the minor folding and crumpling would conceivably create conditions suitable for the accumulation of oil, and the supposed crests of the broad arches which bring the sands of the Dakota nearest to the surface being studied in detail. Previous development in this area has resulted in the hope that oil will be found in commercial quantities provided the drilling is carried to a sufficient depth. Various gas horizons have been successfully tapped and shows of oil have been encountered, and it is only by exploring the lowest beds of the Cretaceous and, if necessary, the Devonian, that these hopes will be either realized or dissipated. The drilling now in progress, or under consideration, should prove to be a fairly conclusive test. Work is being carried on at the following places: In Saskatchewan, near the international boundary, south of Cypress Hills ; on the Saskatchewan River, north of Swift Current ; at Muddy Lake, south-west of Unity ; in Alberta, south of Monitor in the Misty Hills, and near Czar at Tit Hills. Apart altogether from the commercial aspect, the drilling of these wells will be of immense interest to geologists. Starting in the Bearpaw (Pierre) or the uppermost beds of the Belly River, they should, if carried to completion, give a reliable and unique record of the Cretaceous sediments below these horizons and furnish interesting information regarding the attitude and character of the underlying Devonian.

As regards the second division of territory, although exploration in the foot-hills belt was also confined largely to rocks of Cretaceous age, the problems arising differed greatly from those of the plains. At the same time, the two areas have much in common, principally in the amount of attention that has been devoted to them by geologists, and the abundance of literature that has been given to the public. Many prominent geologists have dealt with the various aspects of this area, and one need only turn to their reports to obtain an edifying account of their researches.

The geologists of the Imperial Oil Company set out on their mission well grounded in the general features of the territory. They knew that the Cretaceous rocks had been intensely folded and faulted in proximity to the Rockies, and that, as one travelled eastward, the effects of the great upheavals, complementary to mountain building, gradually diminished until the sedimentary rocks were eventually found in such an attitude as to give favourable structure for the accumulation of oil. Not only so, but rocks, recognized elsewhere as bituminous, were known to underlie the area within convenient reach of the drill. Starting from the international boundary, they followed and mapped these outer folds into the Peace River district, and traversed that river from above Hudson's Hope to 30 miles below Peace River

Landing, the development around the latter place giving this a special interest. As in eastern Alberta, the activities of the geologists were directed mainly to those points which previous research, either by the scientist or by the driller, had brought into prominence. The Calgary boom of 1914 was marked by a great deal of rash speculation and misdirected "wild-catting". There were certain redeeming features, however, notably the development of Western Canada's first producing oilfield in Turner Valley, west of Okotoks. The vast amount of drilling that was undertaken by the various mushroom companies at this time neither proved nor condemned south-western Alberta as an oil-producer. Most of the wells were located at the whim of the driller and without any regard to geological conditions, while those which might have given a fair test were abandoned, owing either to drilling troubles or to lack of funds. The bursting of the bubble left the field discredited to a certain extent in the eyes of the public, but still interesting to the well-informed oil-man. That Imperial Oil still have faith in the future of the area may be gathered from the fact that they have acquired scattered leases over a large area on representative structure, and are drilling, or preparing to drill, a series of wells that should prove an ample test of the foot-hills belt. On a structure designated the Twin Buttes anticline, two wells are being drilled, one within a few miles of the international boundary and the other slightly to the north. On the Willow Creek anticline, west of Nanton, a third well is being drilled, while an endeavour will be made to deepen a well, taken over from another company, in the same territory. All these wells started in Benton shale and production would be looked for in the Dakota, although sandy places of the Benton might give shows of oil.

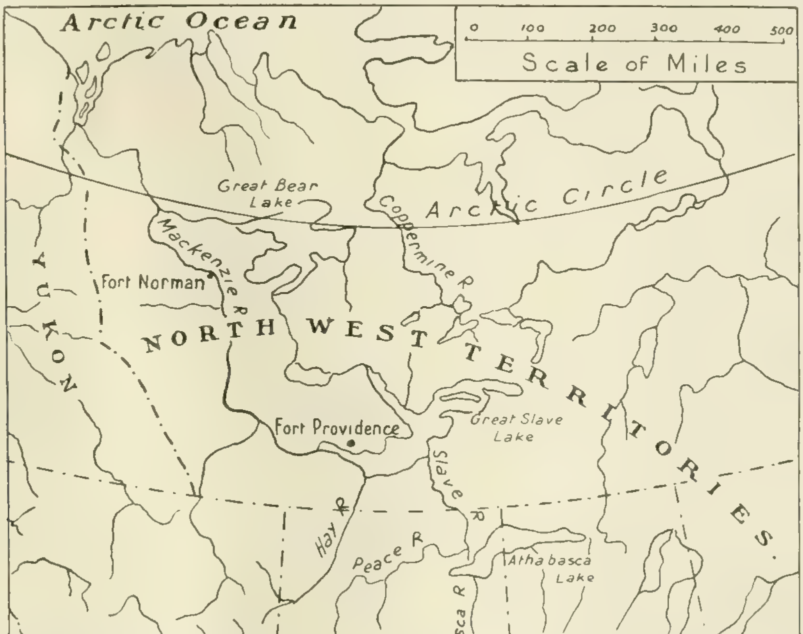
Thanks to the enlightened policy of the government in throwing open the forest reserves to oil investigation, other promising areas have been made available and will probably be tested in the vicinity of Coalspur. Here the structure exposes Belly River strata with very steep dips, and gas seepages have been noted. Deep drilling will probably be necessary, but the chances of obtaining production from the Benton, or even from the lower beds of the Belly River, are not to be overlooked. Favourable indications for oil are found near Pouce Coupe, the rocks at the surface being probably equivalent to the Lower Pierre of eastern Alberta. A test will, in all probability, be made there. Regarding the present field of activity at Peace River, success, if it does come, will probably be attained in the Devonian, the Cretaceous rocks having been drilled into, and through, without exceptional results. There are other structures in the vast area under review that offer possibilities of oil and gas production. It is hoped that other companies will be sufficiently impressed with their possibilities to test them, so that in the near future it may become known whether this area is destined to become a producer of oil or not.

The author proceeds to deal with the Mackenzie River Basin. Exploration of the basin of the Mackenzie dates back to the latter part of the eighteenth century, since which time periodic attempts, more or less successful, have been made to collect information regarding its extent, physical features, and mineral wealth. The full story of these adventures is written in the pages of Canadian history, and the illustrious names of those early *voyageurs* are perpetuated in memorials not made by hands. The geologist was well in evidence in the story of these adventures, and such names as Dawson, McConnell, Bell, Tyrrell, Dowling, Camsell, and Kindle, to mention only a few, are closely connected with the activities of the pioneers. The first investigation of the area on behalf of the petroleum industry, however, was not undertaken until 1914, when Dr. T. O. Bosworth, latterly chief geologist of Imperial Oil, Ltd., covered the whole district from the cities of Alberta to the Arctic Ocean. Dr. Bosworth's paper before the Institution of Petroleum Technologists was quoted in last month's MAGAZINE.

Although the war intervened to hold up development, the project was naturally not lost sight of, and in 1919 two rigs were shipped into the country to locations previously made by Dr. Bosworth, one at Windy Point on Great Slave Lake and the other, destined to become famous, at a point 40 miles down stream from Fort Norman on the Mackenzie. Along with the drilling crews were two parties of geologists who devoted the short season at their disposal to a more careful study of the rocks in the vicinity of the drilling operations. Both drilling and survey work were continued during 1920, the former coming to a promising conclusion in August, and the geologists finding themselves merely on the verge of great areas demanding careful study and painstaking work before their geological history can be written.

In travelling northward on the great waterways the Devonian formation is first found at Crooked Rapids on the Athabasca. Associated with these limestones are "tar sands". The natural oil indications along the Athabasca River are probably the most extensive and conspicuous in the whole world. For a distance of 100 miles a bed of tar sand from 150 to 220 ft. in thickness is almost continuously exposed along the sides of a gorge-like valley, and in many parts cliffs of the tar rock rise steeply from the water's edge to a height of 200 ft. From the exposures on the Athabasca and its tributaries, and by deduction, the existence of the tar sands may be reasonably assumed over an area of 10,000 square miles, probably the largest deposit of asphaltum in the world. The tar sand is a sandstone formation saturated with a dark viscous oil. Originally the rock must have been an ordinary bed of current-bedded sandstone, with some shaly courses, and plant-bearing in places. Courses of finer sandstone or sandy-clay rock, seams of lignite, and thin lenticular seams of concretionary limestone are occasionally found, while, at the base, there are sometimes ferruginous pebbly beds with little oil. As seen at the outcrops, it is a black or dark-brown rock containing from 10 to 30% (by volume) of heavy oil; it is soft and somewhat plastic and, in some instances, oil can be squeezed out by hand. In places, heavy, tarry oil issues slowly from the cliffs and accumulates in holes dug in the outcrop. Chemical analyses show this oil to be of fairly good grade, the chief trouble at present being that it is so viscous that it cannot be pumped from the wells. It has been supposed that the asphaltic material seen at the outcrops of the tar sand is the residue from a vast body of oil from which the light constituents have evaporated. This assumption has led to the drilling of a number of wells back from the outcrop of the sand, with the hope of finding a lighter grade of oil. These hopes have not been realized, however, as the oil found was

almost as viscous as at the outcrop of the sand. It seems possible that, eventually, an oil industry may be established in the Athabasca tar sand region, but whether this will be the result of totally unique methods of extracting the oil from the wells to circumvent its high viscosity, or whether the chemist will devise a means of extracting the oil from the sands by retorting, will only be demonstrated by the march of events.



MAP OF WESTERN CANADA TO ILLUSTRATE THE OIL DEVELOPMENTS.

Nothing need be said of the geology along the waterways until Slave Lake is reached. Travelling eastward from Fort Providence along the shores of that lake, no solid rock is found until after passing Slave Point. On the east side of this is a deep bay about 5 miles wide, having a beach formed of limestone fragments which have been derived from outcrops under the water near at hand. Crossing the bay Brule Point is reached, where the land stands at a higher level. A raised beach, or really a succession of raised beaches, of limestone debris occurs at this place and is traceable eastward for some miles. At Brule Point the waves of the present lake have cut into the older shore-line, forming a cliff about 18 ft. high, capped by loose stones. The lower part of the cliff is composed of fine grey limestone, fissile in parts, smelling strongly of petroleum and containing ill-preserved corals, alveolites, brachiopods, and gasteropods. The same rocks are exposed beneath the water. At Windy Point there are heavy beaches, old and new, consisting of limestone fragments (all

more or less petroliferous but the solid rock is not exposed. About 1½ miles from Windy Point, however, the solid limestone is again seen beneath the water and then for 2 miles further the only evidence is in the beaches. A portion of the shore is now reached where for 3 miles the solid rocks are conspicuous, forming a ragged coast-line with scars of limestone reaching far out into the water. The beds are still dipping in the same direction, but the rock consists of a rough bedded dolomite-limestone of crystalline structure and porous texture, saturated with fluid petroleum which is seeping into the waters of the lake, giving rise to a distinct film of oil on the surface at most parts of the shore for several miles. Where met with inland, for a distance of half a mile, the rock exposures contain small pools of asphalt and oil. Gas seepages have been noticed on the shore and small sulphur springs exist. There is no evidence of structures, and the thickness of the beds is unknown. They have been referred to the Middle Devonian and denominated "Slave Point limestone" and "Presqu'ile dolomite" respectively, and would probably correlate with the Beavertail and Ramparts limestone of the Mackenzie. In the valley of the Hay River, Cretaceous beds, approximately of the same age as the Loon River shales, are found, and also members of the Upper Devonian correlated with the Chemung and Portage. The well now being drilled at Windy Point should give some interesting data regarding the thickness and character of the underlying strata.

DIAMONDIFEROUS BRECCIAS IN BRAZIL

The *Transactions* of the Geological Society of South Africa for 1920 contains a paper by David Draper, the doyen of diamond geologists, on the high-level diamond-bearing breccias at Diamantina, Brazil.

The gravel beds of the Jequitinhonha river, which takes its rise in the Serra do Espinhaco, a few miles south of the town of Diamantina, were, for over a century, the chief source whence diamonds were obtained. During the slave-holding period many thousands of labourers were employed in washing the diamond-yielding gravels, thereby producing wealth to their owners, as well as enriching the impoverished treasury of the Portuguese Government. The discovery of diamonds in the Jequitinhonha dates from the year 1729, and the yield of wealth from this source has not ceased, though greatly diminished, up to the present day. Though the recent river gravels, as well as the ancient terraces, contained a rich crop of diamonds, no one endeavoured to trace the source whence these gems were derived, until an accidental discovery, made by a slave woman, of diamonds in a blue clay on the summit of the watershed that divides the Jequitinhonha and the Sao Francisco rivers, drew attention to the brecciated beds which were situated on the higher ridges flanking the Jequitinhonha. The first of these discoveries, named the St. Joao do Chapada, was exceedingly rich in parts, and subsequently many similar areas were investigated with encouraging results; but owing to the want of water on these high-lying areas, they have all been neglected for many years; yet the future of the diamond industry in Brazil is intimately connected with their development.

The Serra do Espinhaco, rising to a general altitude of about 1,400 metres, with occasional peaks reaching to nearly 2,000 metres, lies about 200 miles inland, with its greatest length, over 1,000 kilometres, roughly parallel with the Atlantic Coast, and its greatest width about 90 kilometres. On the west the Serra do Espinhaco is flanked by the valley of the Sao Francisco river.

The Serra is composed of alternating beds of quartzite and shale of about equal thickness; owing to the severe tilting to which the whole series has been subjected, these beds dip at a general angle of about 45° to the eastward, and in consequence the tilted outcrops of the softer slate beds have been lowered by the forces of atmospheric erosion, and now form flat-bottomed valleys, lying between ridges of quartzite several hundreds of feet high. These valleys continue for short distances in straight lines, but have been forced out of line by numerous cross faultings; crumpling in a most intricate form is occasionally seen, both in the quartzite and in the slates. The quartzite is generally very fine grained, and made up almost entirely of small grains of white quartz; where unweathered it is extremely hard, but decomposes into a soft friable sandstone. The slate beds are generally yellow in colour, distinctly laminated and soft. Those situated near the town of Diamantina are red in colour, and somewhat resemble the Hospital Hill slates of Johannesburg in mineral composition. Conglomerate beds, formed of rounded quartz pebbles in a siliceous cement, are occasionally met with in the quartzite. They closely resemble the conglomerate of the Witwatersrand in appearance, but do not contain gold.

The general aspect of the Serra do Espinhaco is that of a rugged rocky plateau, scored by narrow ravines, of great depth, with precipitous sides. Innumerable ridges of low altitude run parallel with the strike of the formation, and these consist of quartzite, weathered into most fantastic outlines and deeply scored and fissured. A scant vegetation covers the flanks of these ridges, and the valley bottoms; but in general only rock is visible in the higher elevations of the landscape; where slate beds predominate, the valleys are covered with coarse grass and semi-aquatic vegetation. Land suitable for agriculture occurs in small areas in the valleys, but these are few and far between. In such a rugged and desolate country means of communication are bad; beyond the railway station at Diamantina the traveller has only mule transport to depend on for the conveyance of his baggage and himself.

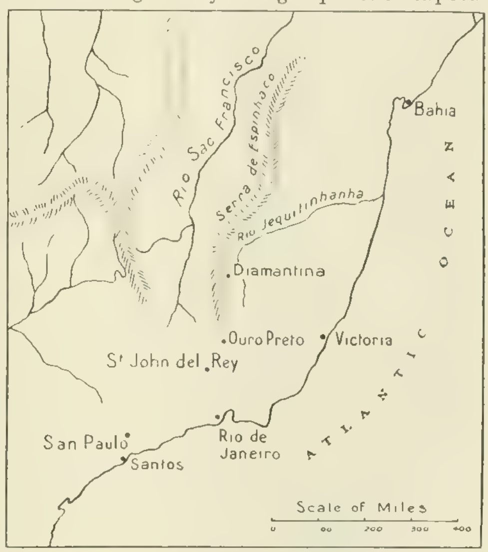
When the earlier diamond seekers discovered that the small tributaries of the Jequitinhonha yielded diamonds, they continued their operations until they extended beyond the level of the water supply. The crude methods then, and still in use, prevented any higher workings; hence the summits of the diamond-bearing mounds remained intact, except in the most favourable localities. By this method many high-level diamond-bearing areas were discovered. The best known of these in the neighbourhood of Diamantina are St. Joao do Chapada, Sopa, Boa Vista, Serrinha, Datas, and a few other of minor importance.

St. Joao do Chapada has been inspected by most of the leading geologists who have visited or been residents of Brazil. Dr. Orville A. Derby, late

State Geologist to the Federal Government of Brazil, in a pamphlet published in 1898, deals fully with the aspect of the great cutting (500 metres in length by 40 in depth) and the occurrence of the diamonds in three distinct veins, one of which was of pegmatitic origin, and the occurrence of kaolin. Unfortunately Dr. Derby did not analyse this mineral. Hausser and Claralz declared the mineral to be hornblende, but Rose failed to find this mineral in the sample examined by him. Later on Harder and Chamberlin, in 1914, described the cutting, but they also refer to the mineral, both at St. Joao do Chapada, as kaolin. Unfortunately they were not able to inspect the mine as the cutting had fallen in, and had been abandoned for the past 12 years. Von Eschwege, Von Helmreichen, Gorciex, and many other noted geologists, inspected the high-level diamond-bearing breccias of Diamantina,* but none of them recorded the chief characteristics which point so conspicuously to their being a unique formation, agreeing in many respects with the kimberlite pipes of South Africa, yet possessing problems which are quite out of the common, and which, until these mines are further developed, will remain in doubt.

Boa Vista is the most extensive of these high-level breccias, and as the writer has now been resident on the property for over a year, and has neglected no opportunity to disentangle the geological puzzle which it presents, it will be described in fuller details. The Boa Vista mine is situated about 12 miles east of Diamantina. Encircled by the quartzite ranges of the Serra do Espinhaco and bounded on the north by the Rio Bon Successo, and on the south by the Rio Fundao, lies a mound about 250 ft. above the flanking valleys, and covered with a scrubby brush vegetation. Though the surrounding country consists of naked quartzite rocks, forming ranges over 1,000 ft. in height, there is no vestige of any mineral matter, other than broken quartz, and nodules of limonite in the red, grey, or yellow soil lying on the surface of the mound, which is over three miles in length and one mile in width. Many small streams flow from the flanks of this mound, and in these diamonds have been found for the past half-century. On the northern slope of the mound there are very extensive workings, occupying over one mile in length, and about 100 yards in width, and in the deepest part over 70 ft. in depth. In these workings very interesting sections of the deposit are obtainable, and they give the following succession of beds: (1) Surface soil varying in depth from a couple of feet to over 25 ft.; (2) brecciated sandstone cemented together by a soft cement; (3) highly decomposed Espinhaco quartz much disturbed, but generally dipping at low angles in various directions. On the northern slope several dykes intersect both the underlying quartzite and the brecciated bed, and where these occur the floor has been faulted, in places for over two feet. The mineral contained in these dykes is so highly decomposed that it is impossible to determine its original composition; as seen at present it resembled a soft soapstone, foliated, and scaly, unctuous to the touch, colour grey, greenish, or yellowish. The disturbance of both the floor and the brecciated beds indicates that these veins are of later origin than the brecciated bed above referred to. The brecciated bed, being the diamond-bearer, is of the greatest economic importance.

A view of any of the worked faces of the great excavation presents the following aspect: angular and sub-angular, rarely round boulders of soft sandstone, differing in bulk from pieces about six inches in diameter to masses over 18 inches in diameter, scattered without regard to size, throughout the mass, but occasionally in layers separated from each other by beds of finely granular talc. When the boulders have unequal diameters their longest section is generally vertical or steeply inclined. The boulders of sandstone are of many different colours, some black and sparkling with small bright crystals of magnetite; others chocolate coloured, red, yellow, or grey, but the light colours predominating. None is hard, but all can be crumbled to pieces by the pressure of the fingers. Rarely do the boulders touch each other in the mass; they are almost invariably separated by a grey or greenish grey cementing mineral, soft and unctuous, differing completely in mineral composition from the boulders. In the cement there are a few egg-shaped pebbles of white or grey quartz, very much fractured and generally falling to pieces on exposure.



Map of the Diamantina District.

The cement also contains magnetite, martite, ilmenite, perofskite, small books, with rounded edges, of phlogopite, a few crystals of black tourmaline, very few garnets, and diamonds. From surface to floor the whole mass is quite soft, though immediately on the sandstone bed it is generally somewhat harder than higher up. In these places an olive green mineral is distinctly in evidence, giving a characteristic colour to the mineral filling the interstices between the boulders. The cement also is harder than the boulders. Thin quartz veins are also in evidence passing from the sandstone floor for a few feet upward into the mass. Like the dykes, these are also of later origin than the brecciated beds.

A description of Boa Vista is, generally speaking, applicable to all of the high-level diamond-bearing deposit of Diamantina. The soft, soapy, talcose mineral is characteristic of them all, but Boa Vista is, owing to its vast size and the great area of old workings, the only one that can be examined to any extent. Workings on all the slopes of the mound, as well as hundreds of prospecting

pits give evidence of the continuation of the breccia with its talcose cement, and the yield of diamonds has proved it to be an area of great economic value. To this may be added that in the neighbouring rivers many falls exist where an ample supply of power can be generated ; that there is no lack of water near the mine for hydraulicking purposes ; and finally that the entire mass of mineral is soft, yielding less than 1 per cent of hard nodules. Under these conditions working expenses are very low, and as the diamonds are of the finest quality, and inferior stones very rare, this great mine, when handled by men of experience, will take its place as one of the great diamond-producers of the world.

Previous writers have all held that these beds are of fluviatile origin, and they have been called conglomerates. Only Gorciex suggested that there is no reason why the diamond may not have been formed in veins in the same manner as topaz and other minerals. This was with reference to the St. Joao do Chapada mine. Harder and Chamberlin distinctly state that these occurrences have been formed by a flowing river, and suggest that by mapping the actual course of this ancient river could be defined. The late Dr. Orville A. Derby informed the writer that he was of opinion that they were the remains of a great transgressional bed of conglomerate that covered large portions of middle Brazil, though he admitted that the Sao Francisco valley was a decided obstacle to this theory. No observer, who is acquainted with the nature of conglomerates, when examining the faces of Boa Vista mine, would for a minute consider them to be conglomerates, formed by fluviatile or glacial means. In true conglomerates the boulders would have been more rounded or egg-shaped. They would have been superimposed on each other, or at any rate more closely crowded together than they are in this bed. Then, again, the fact that the cementing mineral is of a totally different composition from that of the boulders is of very great importance, as well as the origin of the boulders from the beds surrounding the mine. Though quartzite of a very durable nature exists on the hills surrounding the mine, the boulders of similar rock have been reduced, most likely by chemical action, to incoherent sandstones. The fact that the boulders are composed of only one class of rock must also be taken into consideration as opposed to the fluviatile origin of the Boa Vista and other high-level diamond-bearing deposits. But last, and by no means least, there remains the indisputable fact that the diamonds from each individual high-level deposit possess characteristics so distinct from each other that there is no difficulty in determining their origin. Those who favour the fluviatile origin of high-level breccias will have to explain away the foregoing difficulties. A river that could not only sort out the class of boulders, provide them with a cementing matter quite distinct, and at the same time provide each area with diamonds of a different character, would indeed be a great curiosity. Though it is not difficult to bring evidence to controvert the fluviatile theory, it is quite a different matter to provide one that does justice to these unique occurrences.

The kimberlite pipes of South Africa can be so distinctly proved to be of volcanic origin that no one disputes the point at the present time. Kimberlite is largely made up of olivine. Though fresh specimens are unobtainable at any of the Diamantina occurrences, an analysis of the freshest mineral gave a high percentage of magnesia ; some crystals extracted from a groundmass of the cement showed all the characteristics of olivine ; on the other hand, there are no signs of felspar or its decomposition product, kaolin. Talc, however, is abundant in the decomposed cement. The present diamond-bearing rivers of this part of Minas all rise in the great quartzite range known as the Serra do Espinhaco. The Jequitinhonha and the Arrasonahy, both rivers of about equal size, join about 100 kilometres north of Diamantina, yet, though the former was probably the richest diamond-bearing river ever discovered, the latter is not known to contain diamonds. St. Joao do Chapada Mine is over 130 ft. deep, and the diamond-bearing mineral continues still deeper. In places Boa Vista has been worked to a depth of over 70 ft., yet there is absolutely no alteration in the nature or construction of the breccia. There is nothing to indicate that there are any talc beds in the country that could have produced the cementing matter ; all the known igneous dykes which are now reduced to a talcose mineral, are of later origin than the breccia, and consequently they could not have produced the cement. It is therefore essential that some other source of origin should be considered, and after a lengthy study of the subject the writer has come to the conclusion that certain areas in the Serra do Espinhaco, notably those in the vicinity of Diamantina, were subjected to severe dynamic forces, which resulted in the opening of fissures, these forming channels whereby the diamond-bearing mineral, probably kimberlite or some allied rock, in a highly decomposed condition, could reach the surface and where a weakness in the superincumbent strata existed, large masses were formed in the adjacent rock. These, breaking naturally into rectangular fragments, became entangled in the plastic mass, and owing to the higher specific gravity of the cement the masses of lighter sandstone remained in suspension, and were prevented from touching each other, or in many cases from reaching the bottom. A complete intersection of one of those occurrences will in all probability uncover the fissure from where the diamond-bearing mineral has reached its present position.

With the exception of St. Joao do Chapada, to which no bottom has been discovered at a depth of 130 ft., all the other occurrences are only being operated on along the flanks, where a disturbed floor occurs. On the south-western slope of Boa Vista, the Espinhaco quartzite forms a distinct wall over 60 ft. high, bounding the brecciated bed, and on the northern side a vertical wall of talcose rock can be seen to a depth of over 70 ft. ; borings have shown the depth of the deposit at this spot to be over 100 ft., where no bottom rock was encountered.

Though the high level diamond-bearing breccias of Diamantina cannot actually be called " pipes ", there is no doubt that they are of local origin, each one representing a distinct occurrence of diamond-bearing rock, consisting of a talcose mineral forming the cementing matter, in which the brecciated masses of quartzite became entangled, while the mass was in a plastic condition, and finally as there is no evidence regarding the cement having been deposited by the action of surface waters, it must be assumed for the present that it emanated from deep-seated regions and was brought to the surface

through channels, either fissures or circular vents. The Agua Suja diamond mine, situated about 300 miles westward of Diamantina, in many respects resembles the brecciated deposits of Diamantina. When this mine was inspected by the writer about ten years ago he came to the conclusion that the diamond-bearing bed was of local origin, that is to say, that it was formed by the breaking up of a mass of igneous rocks which existed in its immediate vicinity, and as the large boulders were of local origin, the smaller minerals, including the diamond, could not have been brought from distant sources, but were also of local origin. Since that visit the writer has explored the head waters of the Rio Sao Francisco and the Paranahyba, where he discovered a small kimberlite pipe near the town of Patos, and last year specimens of kimberlite were brought from the neighbourhood of Coromandel. These discoveries point to the fact that true kimberlite exists in Brazil, and confirm the author's contention that the Brazilian diamond-bearing rivers have derived their diamond contents from the disintegration of volcanic vents similar in many respects to the South African occurrences.

THE BRITISH AMERICAN NICKEL CORPORATION

In the *Canadian Mining Journal* for March 18, W. A. Carlyle, the managing director, gives an account of the operations of the British American Nickel Corporation. It will be remembered that this company has developed the Murray mine near Sudbury, Ontario, and has erected a smelter near by, together with a refinery near Ottawa, where the Swedish Hybinette process is employed. The Corporation was financed by the British Government as a war measure. Owing to the present fall in the prices and demand for metals, the mine and works were closed shortly after the beginning of this year. We give herewith Mr. Carlyle's description.

The mining lands owned by the company comprise 17,590 acres in the nickel district at Sudbury, of which 12,590 acres are located in the mineral-bearing zone. Most of the diamond-drilling campaign was confined to the Murray mine, where a very large body of ore was thus disclosed, to which all recent mining operations are confined. This ore-body, as determined by vertical drill-holes, 200 ft. apart, outcrops at the surface, and with a very uniform dip of 38° from the horizontal has been shown to extend 3,600 ft. downward on the dip with a thickness varying from 40 to 140 ft. of smelting ore. Within the area drilled lie 16,000,000 tons of ore, averaging 3% of nickel and copper, sufficient to keep the present plants running for 30 years, and the ore-body undoubtedly extends much farther beyond the holes, the deeper of which discloses a great tonnage of higher-grade ore, containing 4% nickel and copper. The ore typical of the district occurs in the norite rocks with a foot-wall of greenstone, and in places, granite; and consists of pyrrhotite with some chalcopyrite. It also contains a small but valuable amount of the rare metals of the platinum group, all of which will be recovered and separated in the refining process.

At the Murray mine a three-compartment inclined shaft in the foot-wall is now down about 1,200 ft. with eight levels opened up, each half in the foot-wall and half in the ore. A unique method of mining the ore has been chosen that will permit the cheap extraction of at least 90% of the whole ore mass. On each of the five levels is a 5 ton Canadian Westinghouse locomotive, with Edison storage-batteries, running on 24 in. tracks laid with 36 lb. rails, and hauling four 4 ton ore-cars of the Granby type. On each level is a motor-generator set for charging the batteries on the third shift. All of this plant is giving great satisfaction. The drilling is done with Waugh No. 21 turbo-hammer drills using 90 to 100 lb. air and hollow steel for water feed. There is a large ore-pocket, with finger-gates below every second level, which loads the 8 ton skips in two compartments of the shaft. On the surface all the buildings are substantial and well built. As enough electric power for the time being could not be obtained, it was decided to instal steam plants at the mine and smelter, but so arranged that every machine could later on be electrically driven. In the mine power house are three 1,000 h.p. Babcock & Wilcox boilers, 160 lb. pressure, equipped with Weir feed-pumps and large steel coal-hoppers with endless pan-conveyors, feeding the chain grates with slack coal. There is a powerful Allis-Chalmers steam-hoist of the latest design, hoisting at the rate of 1,500 ft. per minute, and two Belliss-Morcom air-compressors, each yielding, at 250 r. p. m., 2,500 cu. ft. of free air per minute at 105 lb. There are also two other small compressors, one steam, the other electrically driven, and 6,500 to 7,000 cu. ft. air is altogether available. In the shaft-house the ore from the skips, after passing over grizzlies, goes through a 46 by 48 in. Buchanan-Blake-type rock-crusher into a flat-bottomed bin, which feeds the 36 in. belt, 300 ft. long, to the top of the rock-house, where the rock, after passing over a 2 in. screen, is distributed by a belt along a storage bin, which in turn supplies the seven picking-belts. The mine can easily supply 1,200 to 1,400 tons of mixed ore per day, and 2,400 tons have been hoisted in two shifts. From 20 to 25% of the material hoisted is picked out and sent to the waste dump. The smelting ore, coarse and fine, is taken in 35 ton ore cars 1¼ miles to the smelter ore-bins.

At the smelter the power-house boiler-room contains six 1,000 h.p. Babcock & Wilcox boilers, working at 180 lb. pressure, supplied with superheaters and chain grates, also fed from steel bins filled by the endless bucket-conveyor. Weir pumps supply the boiler feed from a Cochrane preheater. In the blower-room are four turbo-blowers, 3,600 r. p. m., each direct connected to a steam turbine, blowers and turbines being the Rateau-Battu-Smoot design. Two of the blowers each deliver 30,000 cu. ft. free air each at 36 oz. for the blast-furnaces and two 36,000 cu. ft. each at 12 lb. pressure to the converters, the steam turbine for each of these being 2,200 h.p. Each turbine has its surface condenser complete in every detail with centrifugal pumps for returning the hot condensing-water to a cooling pond. One unit comprises a 1,100 h.p. turbine, driving one of the blast-furnace blowers, and a 550 k.w. generator, used when the Wahnapitae power fails, which can be used as a motor to direct-drive one or both blast-furnace blowers. On account of the highly superheated steam, 590 to 610°, it was found necessary to fit the steam governors of all the turbines with monel-metal parts, which has proved very satisfactory.

In the smelter building are two blast furnaces, 50 by 360 in. at the tuyeres, and a third is on the ground. On a strongly constructed crucible, 24 in. high, stands the single row of steel water-jackets, 14 ft. long, 30 in. wide, inner plate $\frac{5}{8}$ in., outer $\frac{3}{8}$ in., with a water space of 5 in. There are two $4\frac{1}{2}$ in. tuyeres in each jacket, or 24 on each side of the furnace. The furnace is tapped at either end, using a water-cooled cast-iron spout for discharging into a settler 20 ft. by 30 ft. by 5 ft., lined with chrome and magnesite bricks, there being three settlers in all. The four matte tap-holes at first gave much trouble, but a syphon tap, invented by J. H. Gillis, solved this difficulty. On the charging floor standard gauge tracks on each side of the furnaces lead to the supply-bins, and a specially designed type of charge-car drawn by electric trolley locomotives gives great satisfaction. Each car is divided into four 4 ton compartments, discharging one side into the four feed openings of the furnace, while in the centre of the other side is a multibeam weighing device, with which the proper weights of coke, ore, and flux can be weighed into each section through the valve-gates in the bottom of the supply-bins. In the converter aisle are two 60 ft. span, 40 ton electric travelling cranes serving the three Peirce-Smith basic-lines converters 13 by 30 ft., each with forty-four $1\frac{1}{2}$ in. tuyeres and electrically rotated. Steel ladles holding 20 tons of matte, or 12 tons of converter slag, are used. The holes soon made in these by the corrosive matte are now very successfully repaired by fitting in pieces of steel plate by thermit welding.

The smelting practice has many features different from that followed by the other smelters in the Sudbury district. The ore averaging SiO_2 24%, Fe 35%, CaO 3·7%, MgO 4·3%, Al_2O_3 6%, S 19%, is smelted without any preliminary roasting, and the only flux used is converter slag containing SiO_2 16%, Fe 52%, CaO 3·5%, Al_2O_3 3·5%, the charge consisting of 70 to 75% ore, the balance flux, with 10·5% coke on the charge. The resulting slags contain SiO_2 35·5%, Fe 30%, CaO 5·5%, Al_2O_3 13%, and 0·24 to 0·34% nickel plus copper plus cobalt. The low-grade matte from this furnace, containing 11 to 13% nickel and copper is poured into the converters, and blown up to the usual matte containing 80 to 82% copper and nickel and a trace of iron, which is transferred to an oil-fired furnace, and in running from thence through a strong stream of water is very successfully granulated, then wheeled into box cars and shipped to the refinery. In the converter method the flux mainly used is ore fines with some silicious gravel or sand. One aim is to keep the silica in the converter slag as low as possible, it often averaging for days under 13%, which eventually will become the regular practice. This slag is poured in part into large 20 ton cars, poured outside the building on to shallow beds lined with ore fines, broken up and lifted by locomotive cranes, using clam-shell buckets, and sent to the smelter bins. Part of the slag is poured into the settlers. The capacity of the blast-furnaces is proving much greater than anticipated, as for the past three months one furnace has averaged over 800 tons of ore per day, and 1,015 tons of ore have been smelted in one day, counting in the ore used as flux in the converters. In the future greater results will be achieved, especially if the ore fines under $1\frac{1}{2}$ in. now going to the furnaces are sintered, a problem now being studied. The amount of flue-dust is small, being caught in the dust flues and chambers. The smelter stack is 300 ft. high and 25 ft. inside diameter.

The refinery is situated at Deschêne, Quebec, near Ottawa, where cheap electric power was available, and other advantageous factors existed, such as an excellent site, water, and sufficent labour. This plant has a capacity of 15,000,000 lb. of nickel per annum, and at a comparatively small expense can be increased to from 20 to 24 million pounds. This metal is deposited electrolytically by the Hybinette process, and a very high-grade product is being produced, containing practically no impurities but a little iron and copper and some hydrogen. The matte from the smelter passes through two Wedge roasters, each with eight hearths, and thence to the leaching department, where the copper in part is dissolved with H_2SO_4 and plated out in the electrolytic tanks, the cathodes being melted down and cast into 81 lb. ingots; about 55 tons of copper is produced per 100 tons of nickel. The leached matte with fluxes is then smelted in especially designed electric furnaces using 24 in. circular carbon electrodes, and nickel-copper anodes, weighing 200 lb., are cast in steel moulds. These furnaces, which are proving a signal success, were designed by Ivar Hole, a Norwegian metallurgical engineer. These anodes then go to the nickel-depositing building, which covers three acres, and not only is the nickel plated out, but a large amount of nickel-sulphate and also nickel-ammonium salt is produced for sale to the nickel-plating industries. The slimes remaining after the nickel anodes are dissolved are collected and concentrated, and will be refined in the precious-metals department to yield platinum, palladium, iridium, rhodium, and some gold and silver.

HERB LAKE GOLD DEPOSIT, MANITOBA

The March *Bulletin* of the Canadian Institute of Mining and Metallurgy contains a paper by F. J. Alcock, a member of the Ontario Geological Survey, on the geology and ore deposits at Herb Lake, at the eastern end of The Pas mineral belt, Manitoba. Herb Lake is at the opposite end of the belt to Flin-Flon Lake, particulars of the geology of which were given in the April issue. The first real interest in the Herb Lake region was aroused in the summer of 1914, when gold-bearing quartz was found on the east shore of Herb Lake, on what is now known as the Kiski claim. Other finds were soon made close to the original discovery, and active prospecting has continued from that time to the present. A considerable amount of development work has been carried out on a number of claims, and on one property, the Rex, a mill has been erected and active mining operations carried on.

The rocks of the Herb Lake district belong to two geological eras. The greater part of the region is underlain by rocks of pre-Cambrian age, but a belt of Palæozoic rocks extends across the southern margin of the region. Since, however, the ores were deposited before the deposition of the Palæozoic rocks, the latter are of no consequence in this connexion. The pre-Cambrian rocks in turn fall into two main divisions: first, granite and its differentiates; and secondly, an older complex consisting of sediments and igneous rocks highly folded, and intruded and metamorphosed by the

granite stocks and batholiths. The igneous members of the pre-granite complex are, to a large extent, of volcanic origin and consist of flows, tuffs, and breccias; intrusive rocks, however, of the composition of diorites, and dykes of lamprophyre and porphyry are also found. In composition there is a wide range from light-coloured, acid rhyolites to dark-coloured greenstone rocks of the composition of basalts. In places, some of the acid types appear to intrude the more basic rocks, but they are all probably related to the same period of igneous activity. Many of the rocks have been altered into schists through regional and contact metamorphism. From basic types, chlorite schist is a common product, and from the acid types, sericite schist. Along the borders of the granite intrusions the common alteration product of the greenstone rocks is hornblende schist.

The sedimentary rocks of the pre-granite complex consist of quartzite and paragneiss with conglomeratic bands, garnet-gneisses and staurolite-bearing and cyanite-bearing schists. These rocks are interbanded with at least part of the volcanic rocks, and the whole is considered to be a thick series of interbedded flows and clastic sediments folded and metamorphosed by granite intrusions. A great erosional unconformity separates all these rocks from the flat-lying Ordovician dolomite along the southern shore of Herb Lake. A mantle of clay, laid down in post-glacial Lake Agassiz, covers much of the area and renders prospecting locally difficult. The areas of muskeg are equally disadvantageous in this regard.

The gold deposits are in the form of veins which are found traversing all the pre-Cambrian rocks of the area. They are considered to be genetically related to the granite intrusions. The evidence leading to this conclusion may be briefly cited. The granite with its differentiatesforms the youngest intrusive of the region; since quartz veins are found traversing even the granite, they have either been derived from it or from some other intrusive that is not exposed at the surface. Again, many of the quartz veins contain felspar, and a number of gradational types between true quartz veins and pegmatite dykes were found; since the pegmatites were clearly derived from granite intrusions, it is necessary to postulate a similar origin for the quartz veins. The mineralogy of the veins is also significant. Tourmaline, which is a common pneumatolytic mineral associated with granites and pegmatites, is present in nearly all the veins. Arsenopyrite is also very common in the quartz and is locally found disseminated in the granite as an original constituent. The geographic distribution of the main veins at Herb Lake is likewise suggestive. The main veins lie near the border of a granite stock which is situated between the Grass River and Little Herb Bay. This stock has produced extensive contact metamorphism with the development of garnetiferous and staurolite-bearing schist in the zone surrounding it, and has almost certainly been responsible for the formation of the veins. This suggests that the most favourable places for prospecting should be along the borders of similar stocks.

Most of the deposits are fissure veins with sharply defined walls. Along some of the veins, however, the country rock has been extensively altered, giving rise to a border zone of sulphides and carbonate rock, a zone that in places carries gold. The deposits are for the most part lenticular, with pinches and swells. Many of them follow the rock structure, either bedding or schistosity, and as a rule small stringers are parallel. The veins lie in various types of country rock; several of the important veins of the area occur in a rhyolite-porphyry, a possible reason for this being that its hard, massive character is more favourable for the preservation of fissures than the softer, more schistose rocks.

The quartz of the veins varies to a considerable extent. Many of the barren veins consist of white quartz with practically no mineralization. In the gold-bearing veins, the quartz varies from white to brownish in colour, and from granular to coarse vitreous in texture. The variety that, as a rule, carries the best value in gold is a fine, granular type traversed by dark streaks. These streaks, for the most part, are short and irregular, and along them is concentrated most of the mineralization, consisting of black tourmaline, sulphides, and the greater part of the gold. In places, however, needles of tourmaline, specks of sulphides, and gold in visible quantities are found in the quartz away from any of these dark streaks. Of the sulphides, arsenopyrite is the most abundant, but pyrite, chalcopyrite, galena, and blende are also found. Felspar crystals are sometimes found in the veins, and on the Moosehorn claim a telluride, probably petzite, was found associated with some of the gold particles. The absence of any well-banded structure in the quartz, and the association of the gold with the sulphides, and more particularly with the tourmaline, is evidence that the ore was deposited under conditions of high temperature. In a number of specimens collected, gold in visible quantities was found completely enclosed in masses of tourmaline, showing that the same origin must be assigned to both minerals.

To summarize, therefore, it is believed that the gold-bearing veins of the region are high temperature deposits genetically related to intrusions of granite. These intrusions were accompanied by deformation which produced fractures, shear planes, anticlinal openings, and other lines of weakness. As the intrusive mass cooled and commenced to solidify, the volatile constituents became progressively more and more concentrated in the remaining liquid part of the magma, and during the late stages of the intrusion, were finally given off forming pegmatite dykes and quartz veins. The formation of the veins was a process which proceeded slowly and in places the primary quartz was crushed, and minerals, including gold, were deposited in the fractured areas; but the whole was essentially one process related to the granite intrusion. Fractures would naturally be more abundant in the roof of the batholith, and it would be along these lines that the ascending solutions would escape; veins would therefore be more numerous along the upper parts of the intrusion. In the long period separating the time of the intrusion and the deposition of the Ordovician dolomite, the region suffered extensive denudation, with the result that the roofs of the batholiths were nearly everywhere stripped off and the upper parts of the batholiths themselves removed. This erosion meant the destruction of many valuable ore deposits. In other places, however, where the intrusions did not come so near the surface, erosion has uncovered only the irregular upper parts of the batholiths, parts which would appear on a surface map as small stocks. These consequently are more favourable places for

prospecting than where wide areas of granite are now found. It must be remembered, however, that any area where rocks of the pre-granite complex are exposed may be underlain at no great depth by intrusive masses and hence be mineralized. Solutions also may travel considerable distances from their parent magma. The Rex vein lies at a distance of over a mile from the nearest surface exposure of granite, and the Kiski veins at a distance of nearly 3 miles. The Twin Lakes property shows that, even in the borders of the granite stocks, deposits of ore may be found.

The only property on which active mining and milling operations have been performed is the Rex. During 1918, work was carried on from May until December, when the plant was closed. Work was resumed in the spring of 1920. The vein lies approximately 200 ft. from the shore of Wekusko lake. It strikes 20° east of north and has been traced for a distance of 1,700 ft. It maintains a width of from 2 to 5 ft. for most of its length, but at two places it swells to a width of over 15 ft., and at others it pinches to less than 1 ft. The vein follows closely a contact between a rhyolite-porphyry and a conglomeratic sediment. As far as work has progressed, the gold persists in depth; an interesting feature in connexion with the ore-shoot that is being mined at present is the fact that, so far as its outlines have been determined by sampling on the surface and underground, it seems to have vertical boundaries.

The Northern Manitoba group is a property consisting of two claims, the Moosehorn and the Ballast, on which is exposed a vein approximately 300 ft. long and varying in width from 6 in. to over 2 ft. A shaft has been sunk to a depth of 100 ft., and 50 ft. of driving has been done. One carload of ore amounting to 57,000 lb. was shipped to Trail, B.C., the returns on which amounted to $2,323, an average of $81·53 in gold per ton.

On the Kiski-Wekusko, the original discovery in the area, three main veins are exposed. No. 1 has been stripped for over 700 ft. and has an average width of 3½ ft., at one point swelling to a width of 12 ft. No. 2 has been stripped for 500 ft. and traced much farther; it has an average width of 3 ft. and at one place is 12 ft. wide. A vertical shaft has been sunk to a depth of 53 ft. on this vein. No. 3 vein has been traced for about 100 ft. It carries gold in visible quantities. Other veins and exposures of quartz have been proved to occur on the property.

On the Elizabeth-Dauphin claims, the Elizabeth vein lies 1½ miles north-east of the Rex. It has an exposed length of over 800 ft. and a width of from 2 to 6 ft. A shaft has been sunk to a depth of 50 ft.

On the Bingo, several small veins have been uncovered. The largest varies from 7 in. to over a foot in width. Gold is present in visible amounts.

The McCafferty vein has been traced by stripping and trenching for over 1,600 ft. Its width varies to over 8 ft.

The discovery on the Apex group is a mineralized zone in red granite. The rock which carries the ore is much like the regional red granite, but is lighter in colour and may best be described as a fine-grained pegmatite. It is more quartzose than the granite, and grades, by loss of felspar, into typical quartz-vein material. The contact between the pegmatite and the granite is locally distinct, but, in places, it is difficult to distinguish the two types. In such places the lode is recognized by the presence of sulphides of which arsenopyrite is the most abundant. The mineralized zone is irregular; at one place it has a width of 40 ft. In places the granite is shattered and small quartz stringers form a stockwork. The irregular character of the deposits makes it difficult to estimate its value.

ANACONDA ELECTROLYTIC ZINC

In the May issue we gave some quotations from the paper by Frederick Laist and others presented to the American Institute of Mining and Metallurgical Engineers. We continue this abstract herewith.

Electrolytic Practice.—The tank house contains 864 cells divided into six units. The cells are 10 ft. 3 in. long, 2 ft. 10 in. wide, by 5 ft. deep. They are made of wood with a lead lining. Each cell contains 28 anodes and 27 cathodes. The anodes are made of chemical lead, and the cathodes of aluminium.

The authors give particulars relating to the effect of impurities in the solution.

In minute amounts, 10 mg. per litre of solution or less, copper does not appear to have much effect on the zinc deposit. In larger amounts, holes are eaten through the cathodes, leaving a black deposit on the aluminium surface; at times a bright deposit of copper is obtained. A second deposition of zinc will not take place until the aluminium sheet is thoroughly cleaned of the black deposit. If copper is the only injurious impurity present, the zinc deposit where not corroded will be firm and bright. High acids are conducive to active corrosion of the impure copper-zinc deposit. Copper attacks the surface of the aluminium sheet, which becomes so smooth that zinc will not adhere until it has been resurfaced.

Antimony is the worst impurity. The presence of any amount that can be determined (one part per 1,000,000) will give a very low current efficiency and a badly sprouted deposit, which results in low melting recovery. The deposit, when held to the light, shows a network resembling a lace curtain, and is lifeless, retaining any form into which it is bent without even partly recovering its original form. The presence of antimony in the zinc deposit has not been detected although present in the electrolyte in appreciable quantities.

The presence of 1 mg. of arsenic per litre in the electrolyte will make itself known at the end of 30 or 40 hours in a type of cathode corrosion peculiar to arsenic. The surface of the deposit becomes rough in appearance and loses its lustre. As this condition proceeds corrugations develop. Larger amounts of arsenic give a badly sprouted deposit similar in appearance to that caused by antimony. After completely re-dissolving the zinc deposit from a portion of the aluminium surface, a second period of deposition will begin, and as many as four depositions have been noticed for a single 48 hour period.

The presence of iron in the electrolyte in moderate amounts does not injure the current efficiency, although when oxidized it causes the aluminium cathode sheets to deteriorate rapidly and, therefore, it should be oxidized and precipitated in the neutral

leach and not allowed to overflow the neutral settlers. During the month of February, 1917, from 25 to 30 tons of chamber acid were added to the plant solution. The acid contained approximately 500 mg. of arsenic per litre ; it was necessary to add scrap iron to ensure arsenic removal. The iron in the purified solution at times was over 0·2 gm. per litre ; it averaged 0·13 gm. per litre for the month. Sufficient iron was oxidized in passing through the cells to provide the necessary ferric iron for arsenic removal. The electrolyte was of a greenish colour throughout the cell system, and apparently no permanganic acid or manganese dioxide was formed, as only about one-half of the iron was oxidized. After a month's trial, it was decided that, due to the deleterious effect of the iron on the aluminium cathodes, the continuous use of the high iron was not justified, although the plant averaged 89·3% current efficiency and yielded 12·3 lb. per horse-power-day for the month. The aluminium cathodes showed marked corrosion at the solution line and along the edges.

Manganese, in the absence of other impurities, has little, if any, effect on the zinc deposit. In the higher states of oxidation, as it exists in the cell, it aids re-solution of the deposit when started by other impurities. Pure zinc will dissolve more rapidly in cell solution than in pure dilute sulphuric acid, owing to the oxidizing effect of the manganese. Where cobalt is present in solution, it is claimed by other experimenters that at least a portion of the cobalt is precipitated by the manganese dioxide in the cell. It is also claimed that manganese protects the lead anodes from corrosion and that the deposit of manganese dioxide is beneficial. The authors insist that this manganese dioxide deposit must be removed at least once every six weeks.

The presence of 0·6 gm. per litre of cadmium in the electrolyte does not injure current efficiency or the character of the zinc deposit. To make grade "A" zinc, the cadmium must be under 20 mg. per litre in the purified solution.

Chlorine, in some forms, attacks the anode very violently when present in amounts of 50 mg. per litre or more. The cathode deposit does not appear to be affected by it.

Nitrates are undesirable as regards anode corrosion, especially in the presence of chlorine. The cumulative effect of the two is worse than either one alone.

Cobalt, nickel, tellurium, and selenium have not been investigated sufficiently to warrant definite statements. Sodium and potassium have no deleterious effect in moderate amounts when present as sulphates.

The corrosive effect of impurities increases greatly with the temperature. Since any re-solution causes an increase in temperature, and an increased temperature hastens re-solution, it is sometimes hard to tell which is the cause and which the effect. With slightly impure solution, it is possible to maintain a fair current efficiency if the temperature can be kept down ; this suggests the use of more cooling coils. With pure solution, a moderate rise in temperature, say from 35° to 70° C., does not cause a falling off in efficiency or change the character of the deposit ; more effort should be spent in purifying the solution instead of providing extra cooling.

If a solid in suspension is a conductor, such as manganese dioxide or carbon, it will cause sprouting of the cathode metal. The electrolyte should be clarified before going to the cells and all foreign matter should be kept out of the electrolyte. When the cells become foul with manganese dioxide, so that it is in suspension, sprouting is more prevalent than at other times. The sprouting is always more intense on the bottom of the cathodes, where there is a higher concentration of the suspended particles.

It has long been the practice in electrolytic copper refining to add moderate amounts of glue at regular intervals. At the suggestion of Willis T. Burns, glue was tried and found to be beneficial. Too much glue causes brittle metal, starts re-solution of the zinc deposit, and may prevent the deposition of any zinc ; the addition of moderate amounts will greatly retard sprouting and give better current efficiency, especially when small amounts of ar enic and antimony are present. After the add t on of glue there is a slight voltage rise and the gas bubbles from the cathode deposit greatly increase in size, probably due to a change in the character of the surface film of the electrolyte. Glue appears to make this film tougher so that the bubbles of gas hang on to the sprouts and raised spots for a longer period, partly insulating them. The low places in the deposit appear to build up faster, giving a much denser deposit with glue than without it. The effect of the glue on the electrolyte only lasts for a short period. Evidently the glue is decomposed, because during periods of re-solution when an excessive amount of gas is coming off it must be added more often. With pure electrolyte, the addition of the glue is not necessary. But the effort should be made to purify the electrolyte, instead of doping it. Sugar, wood juice, starch, and a number of other agents give approximately the same results, but glue is the most trustworthy and cheapest.

Casting Practice.—The zinc-casting plant contains two coal-fired reverberatories with a capacity of from 100 to 125 tons per furnace and one electric furnace with a daily rated capacity of 200 tons. After a six-months' trial the use of the electric furnace was discontinued for the following reasons : (1) When melting zinc cathodes, the dross formed coats over the surface of the metal, preventing the transfer of heat to the bath. (2) It is impossible to get nearly the full production without volatilizing considerable metal ; with a production of 170 tons per day, over 3½% of the zinc charged is volatilized. (3) The metal bath cools during charging so that heat is required in the muffles to keep the metal hot enough for casting. (4) At 70 tons capacity the furnace compares very favourably with the coal-fired furnaces, but when the investment is considered the furnace is a failure for zinc-cathode melting. (5) The heat in the resistor troughs is so intense, when melting 100 tons per day, that the trough construction will not stand up, causing frequent long delays for repairs. The work of this furnace confirmed the laboratory experiments, that when zinc cathodes are melted they will produce a definite amount of dross. To get a good melting recovery the dross must be worked to separate the metal from the oxide.

Zinc cathode sheets are apt to be porous to a certain extent and one side is covered with sprouts or raised spots. There is also a coating of zinc sulphate. Even when melted in a covered crucible, from 4 to 5% of dross is formed. This dross contains metallics and may be reduced 40 or 50% in weight if worked hot with ammonium chloride. The best recovery of the metal over a month's

operation was 96[illegible]; 3[illegible]% of the metal went to form dross, which [illegible] saved 8[illegible]% zinc.

The zinc melting reverberatories are made of common brick below the metal line and of firebrick above. To avoid metal leakage the whole furnace is set on a sheet metal pan, which is supported by I beams set on concrete piers. This construction permits air cooling at the bottom. The main chamber of the reverberatories is built rather high so that there is a deep bath of metal and a big stack of cathodes at all times; this gives a large surface of metal exposed to the heat. The melting zinc running down the surface of the stack carries away the dross and always presents a new surface of bright metal to the hot gases from the firebox, which is large and deep. It is operated as a partial gas producer so that the resulting gases will be reducing, to avoid oxidation of the metal. The dross from the melting cathodes is carried down with the molten zinc and floats on the top of the bath, gradually slowing up the furnace. At intervals this dross is rabbled with ammonium chloride, which causes the particles of molten zinc to combine and sink into the bath. Once every 24 hours the dry dross is completely removed from the furnace and further worked, while hot, in a revolving cement mixer, to which oil and ammonium chloride are added. The addition of a small amount of oil and sawdust to the dross helps to keep up the temperature. Approximately 50% of the zinc contained in the furnace dross is recovered as metal in this way. This metal collects in the bottom of the cement mixer and is tapped out through a hole into moulds.

The loaded cathode cars are brought to the charging stand over which there is a one-ton electric hoist, which places 4 or 5 tons of the cathodes upon a roller coaster. This conveys the metal to the charging doors in the top of the furnace; when the charging door is swung open and the brake on the roller coaster released the bundle of cathodes slides into the furnace. It is only necessary for the furnace to be open a few seconds while charging. Every precaution is taken to exclude the air from the furnace while melting; all openings are sealed except during the dross-skimming period. The furnace is allowed to cool down about 150° C. before opening it to skim the dross.

The molten metal is dipped from metal sealed dipping muffles and poured into 50 lb. slab moulds of which there are 40 in line with each muffle. The dipping ladles hold over 200 lb. of molten zinc and are carried from an overhead crawl. Each is operated by one ladleman who has a helper to mark and stack back the slabs from the moulds. A sample of metal is taken from every twentieth ladle and cast in pencils in a split graphite mould; these pencils are broken up and combined to form the sample representing each day's production.

Zinc-Dust Plant.—Approximately 8% of the zinc produced in the tank room is required to precipitate copper and cadmium. The zinc atomizing plant is made in two units, and either may be shut down without interfering with the other. Each unit consists of an oil-fired Rockwell furnace, two blowing nozzles, and a settling chamber, with a superimposed bag house. The Rockwell furnace receives the molten zinc from the melting furnace by means of an electric hoist ladle and crawl system. The carbon crucible of the Rockwell furnace is provided with two carbon rods in the bottom, tapped with $\frac{1}{8}$ in. holes through which the molten zinc flows to the atomizing nozzles. Air from the nozzles strikes the hot zinc at right angles and blows it into the settling chamber. This chamber has bags above through which the air is filtered, leaving the dust to drop back into the hoppers which are provided in the bottom of the chamber to draw the dust into cars. There are three factors to be considered: (1) The metal must be hot; (2) the air pressure should be at least 85 lb. at the nozzle; (3) the stream of metal should be small, not over $\frac{3}{16}$ in. in diameter. If the air pressure at the nozzle is 300 lb. less attention must be paid to the other two factors.

The authors also give an account of the treatment of residues for the extraction of copper and lead, and they discuss in detail a great many theoretical and practical points connected with the various stages of the process and plant.

SHORT NOTICES

Open-cut Mining.—In the *Mining and Scientific Press* for April 16, A. B. Parsons describes open-cut mining by steam-shovel as practised at the Nevada Consolidated's copper mines.

Winding Engine at Quincy.—The *Engineer* for May 20 describes a large new winding engine at the Quincy copper mine, Lake Superior. It is a 4-cylinder, cross-compound condensing engine, with a 30 ft. drum, and is capable of raising ten-ton loads with a rope speed of 3,200 ft. per minute from depths of 6,600 ft. to 8,600 ft. on the incline.

Mining at Fresnillo.—In the *Engineering and Mining Journal for* May 7, D. B. McAllister describes the new mining methods at the Fresnillo silver mines, Mexico.

Rehabilitation of French Mines.—*Engineering* for May 20 commences an article on the rehabilitation of French coal mines destroyed by the Germans during the war.

Concrete Shafts.—In the *Engineering and Mining Journal* for April 23, J. H. Stovel describes the concreting of two vertical shafts in iron minse in Alabama.

Concrete Shaft-Lining.—In the *Mining and Scientific Press* for April 30, A. B. Parsons describes the concrete shaft of the Chief Consolidated Mining Co., at Eureka, Utah.

Drill-steel.—The American Institute of Mining and Metallurgical Engineers has published a paper by B. Tillson on the breakage and heat treatment of rock-drill steel.

Stope Survey.—In a paper presented at the May meeting of the Institution of Mining and Metallurgy, F. P. Caddy described the method of stope measuring at the Passagem mine, Brazil.

Surveying Instruments.—The *Camborne School of Mines Magazine* for May contains a paper by W. H. Connell, of T. Cooke & Sons, Ltd., on the renaissance of British instrument making.

Electrical Prospecting.—The *Engineering and Mining Journal* for May 7 and 14 contains an abbreviated translation of a paper by C. Schlumberger on underground prospecting by electric current.

Valuation of Mineral Properties.—The *Iron and Coal Trades Review* for May 13 quotes from a paper by T. A. O'Donahue on the valuation of mineral properties, with special reference to post-war conditions.

Cleaning Blast-Furnace Gas.—A paper was read by S. H. Fowles at the May meeting of the Iron and Steel Institute on the cleaning of blast-furnace gas, dealing particularly with the Halberg-Beth plant.

Electrostatic Precipitation.—The *Mining and Scientific Press* for April 9 contains a description of the Cottrell electrostatic fume-precipitation process. Attached to it is a useful bibliography on the subject.

Electrolytic Zinc.—In *Chemical and Metallurgical Engineering* for April 20, H. R. Hanley writes on the removal of arsenic from zinc electrolyte by means of sulphuretted hydrogen.

Copper in Molybdenum Ores.—In *Chemical and Metallurgical Engineering* for May 11, J. P. Bonardi and M. Shapiro describe methods for removing all copper from molybdenum ores before smelting for ferro-molybdenum, and also point out precautions necessary in the analysis for copper in the presence of molybdenum.

Nickel Alloys.—In *Chemical and Metallurgical Engineering* for April 13, P. D. Merica describes a great number of nickel alloys used where resistance to acid and high-temperature steam is desired, and also alloys for electrical purposes.

Aluminium in Engineering.—In the *Engineer* for May 6, J. G. A. Rhodin commences a series of articles on aluminium and its alloys in engineering.

Tin in New Mexico.—In the *Mining and Scientific Press* for April 23, F. S. Naething describes the Black Range tin district, New Mexico.

Quicksilver in Spain.—In the *Mining and Scientific Press* for April 23, H. W. Gould describes the quicksilver mining and metallurgy at Almaden, Spain.

The Earth's Crust.—The *Geographical Journal* for May contains the report of a lecture by Colonel E. A. Tandy, giving some novel views following the theory of isostasy.

Mackenzie River Oilfields.—The *Canadian Mining Journal* for May 6 contains a paper by E. M Kindle containing general suggestions to oil prospectors in the Mackenzie River oilfields.

Origin of Petroleum.—At the meeting of the Institution of Petroleum Technologists held on May 10, P. Carmody read a paper recommending that a special study as to the origin of petroleum should be made at Trinidad, where a greater variety of oils, gas, bitumen, and pitch are found than anywhere else in the world.

Alsatian Potash.—In *Chemical and Metallurgical Engineering*, H. Vigneron describes the Alsatian potash industry.

Californian Potash.—In *Chemical and Metallurgical Engineering* for April 20, L. W. Chapman describes the refining plants at Owens and Searles Lakes, used in separating carbonate of soda, common salt, sodium borate, and potassium chloride from the natural deposits.

Borate Deposits.—In *Economic Geology* for May, N. F. Foshag discusses the origin of colemanite, the borate of lime, found in California.

Vanadiferous Asphaltites.—In the *Engineering and Mining Journal* for May 7, J. G. Baragwanath describes the asphaltites occurring in Peru; these contain vanadium, but not in sufficient quantities to make extraction profitable.

Salt Deposits in Nigeria.— The *Bulletin* of the Imperial Institute, No. 4, 1920, just published, contains a report on samples of sodium, potassium, and magnesium salts found in Nigeria.

Trevithick in Peru.—In the *Engineering and Mining Journal* for April 16, W. B. Paley gives an account of the steam engines built by Trevithick at Cerro de Pasco and elsewhere in Peru.

Alignment Charts.—In a paper presented at the May meeting of the Institution of Mining and Metallurgy, J. A. P. Gibb drew attention to the advantages of alignment charts over intercept and correlation charts and gave a number of applications of this system of calculation.

Scottish Water-power. –*Engineering* for May 20 contains further details of the new hydro-electric power scheme of the British Aluminium Company.

RECENT PATENTS PUBLISHED

A copy of the specification of any of the patents mentioned in this column can be obtained by sending 1s. to the Patent Office, Southampton Buildings, Chancery Lane, London, W.C. 2, with a note of the number and year of the patent.

9,155 of 1919 (140,039). Société Belge d'Outillage Pneumatique (Ateliers Rorive), Brussels. Improved construction of hand hammer-drills.

31,791 of 1919 (162,026). F. E. Elmore, London. In the treatment of argentiferous zinc-lead sulphides, mixing with an excess of common salt or other chloride and heating to a temperature of 450° to 500° C. At this temperature the silver and lead are chloridized but not volatilized, while the zinc sulphide is unaltered.

31,936 of 1919 (162,030). S. Field and Metals Extraction Corporation, London. In removing impurities from zinc sulphate solutions before electrolysing the addition of mercuric sulphate and zinc dust or aluminium or an aluminium-zinc alloy.

32,539 of 1919 (137,288). J. A. Thibault, Paris. Method of producing litharge and red lead from metallic lead.

821 of 1920 (161,654). P. A. Mackay, London. For recovering tin from scrap tinplate by dipping the scrap in oleum, that is, sulphuric acid containing free SO_3.

822 of 1920 (161,655). P. A. Mackay, London. For the purpose of making strontium and barium sulphates opaque, placing them after fine grinding in oleum, or strong sulphuric acid.

823 of 1920 (161,656). P. A. Mackay, London. Method of obtaining copper sulphate direct from metallic copper.

1,231 of 1920 (161,310). H. G. Wildman, Westmount, Quebec. Making alumina from common clay by boiling it in an alkaline solution, then treating with sulphurous acid, which makes aluminium sulphite, the latter being readily split into alumina and sulphurous acid.

1,240 of 1920 (162,038). C. Ellis, New York. Method of producing finely divided metals or suboxides.

2,245 of 1920 (162,082). C. M. Conder and G. T. Vivian, Camborne. A stamp-mill in which the tappet head and shoe are mounted to a beam at right angles, the other end of which is pivoted, the raising cam actuating the beam at the end near the tappet head.

3,640 of 1920 (161,761). G. H. T. Rayner and P. Rayner, Sheffield. Improvements in the valve arrangement of the inventors' patent 138,304.

3,692 of 1920 (161,375). E. C. Vigeon and J. McConway, Hebburn-on-Tyne. An apparatus for evenly moistening roasted ore before being sent to leaching tanks, the object being to avoid dust and the formation of lumps.

NEW BOOKS, PAMPHLETS, Etc.

[illegible] *The Mining Magazine* [illegible]

The Oil and Petroleum Manual, 1921. By WALTER R. SKINNER. Cloth, octavo, 320 pages. Price 7s. 6d. net. London: Walter R. Skinner, 11 and 12 Clements Lane, E.C.4. This is the twelfth yearly issue of a well known publication which gives particulars of all the oil and petroleum companies known in England.

The Petroleum Year Book, 1921. By SYDNEY H. NORTH. Cloth, octavo, 280 pages. Price 10s. 6d. net. London: The St. James's Press.

Copper Refining. By LAWRENCE ADDICKS. Cloth, octavo, 220 pages. Price 17s. net. New York and London: McGraw-Hill Book Company.

Technical Methods of Analysis, as employed in the laboratories of Arthur D. Little, Inc. By R. C. GRIFFIN. Cloth, octavo, 670 pages. Price 33s. net. New York and London: McGraw-Hill Book Company.

Metallic Alloys: their Structure and Constitution. By Dr. G. H. GULLIVER. Fourth edition. Cloth, octavo, 440 pages, illustrated. Price 15s. net. London: Charles Griffin & Co., Ltd.

Problems in Land and Mine Surveying. By DANIEL DAVIES. Second edition. Cloth, octavo, 350 pages, illustrated. Price 12s. 6d. net. London: Charles Griffin & Co., Ltd.

Text-book of Practical Hydraulics. By JAMES PARK. Second edition. Cloth, octavo, 310 pages, illustrated. Price, 21s. net. London: Charles Griffin & Co., Ltd.

Compressed-air Plant. By ROBERT PEELE. Fourth edition. Cloth, octavo, 500 pages, illustrated. Price 25s. net. New York: John Wiley & Sons; London: Chapman & Hall, Ltd.

Pumping by Compressed Air. By EDMUND M. IVENS. Second edition. Cloth, octavo, 270 pages illustrated. Price 22s. net. New York: John Wiley & Sons; London: Chapman & Hall, Ltd.

Salt and Gypsum Resources of South Australia. By R. LOCKHART JACK. Bulletin No. 8 of the Geological Survey of South Africa.

COMPANY REPORTS

Waihi Gold.—This company has been operating a gold mine in New Zealand since 1887. Regular production began in 1892, and the first dividend was paid for the year 1893. The output and profits gradually increased, and were on a large scale from 1901 to 1910. Afterwards the operations contracted owing to the impoverishment of the ore in depth. The report for the year 1920 shows that 159,308 tons of ore was raised, of which 42,066 tons came from the Martha lode, 34,241 tons from the Royal, 19,839 tons from the Edward, 14,599 tons from the Empire, and the remainder from sixteen other places. The average assay of the ore was 6·6 dwt. gold and 2¾ oz. silver per ton. The yield of bullion, taking gold at 84s. per oz. and silver at 2s. per oz., was estimated to be worth £242,264. The actual amount received was £341,432. The working profit was £146,811, out of which £99,181 was distributed as dividend, being at the rate of 20% tax paid, while £47,629 was paid as income tax and £14,907 was written off for depreciation. The ore reserve is estimated at 778,565 tons, averaging 33s. 9d. per ton with gold at par and silver at 2s. per oz.; of this amount 254,737 tons is not immediately available for extraction. Development disclosed 116,521 tons of ore during the year. Additional electric pumping plant has arrived at the mine, so that it is now possible to sink deeper. A thirteenth level is being opened from No. 4 shaft. Since the beginning of operations the income from the sale of gold has been £12,987,603, out of which £5,172,808 has been distributed as dividends, tax paid.

Golden Horse-Shoe Estates.—This company was formed in 1899 to acquire property at Kalgoorlie, West Australia. Very large profits were made from 1900 to 1909, but since then the output and dividends have been much lower. The report for 1920 shows that 125,340 long tons of ore yielded 54,574 oz. of gold, which realized £324,460, of which £87,223 represented premium. The net profit was £65,489, while £75,000 was distributed as dividend, being at the rate of 5%. The development was restricted owing to labour shortage, as was the case the year before. J. W. Sutherland, the manager, estimates the reserve at 637,330 tons, averaging 8·75 dwt. per ton, as compared with 678,296 tons averaging 9 dwt. the year before. The working cost was 37s. per ton, as compared with 32s 6d. in 1919 and 22s. in 1914. The total output of ore since the beginning has been 4,253,635 tons, and the total yield of gold 2,688,840 oz., while £3,517,500 has been distributed in dividends.

Balaghat Gold Mines.—This company operates a gold mine in the Kolar district, Mysore State, South India, belonging to the John Taylor & Sons group. It has not been so important a producer as the other members of the group, Mysore, Champion Reef, Nundydroog, and Ooregum. Eighteen months ago it was reconstructed so as to provide additional funds for a resumption of development. The report now issued covers the fourteen months ended December 31 last. During this period 45,050 tons of ore was milled, yielding 25,833 oz. of gold, and 76,250 tons of tailing was cyanided, yielding 6,629 oz., making a total yield of 32,462 oz., which sold for £163,715. The working cost was £123,454, and after the payment of royalty the profit was £33,296, out of which £23,318 has been distributed as dividend, being 2s. 4½d. on the 10% preference shares, and 1s. 1½d. on the ordinary shares, both of 10s. each. During the year driving on the rich ore-shoot on the 2,600 ft. level was continued, and its total length was found to be 842 ft., averaging 33½ dwt. per ton over a width of 40 in. At the deeper levels nothing further was discovered, though the drive on the 4,000 ft. level is giving promising results. The reserve was estimated on December 31 at 91,755 tons, an increase of 16,725 tons during the year. There is also 177,000 tons of accumulated tailing awaiting treatment. A new sand plant, with a capacity of 4,000 tons per month, is in course of erection. This will replace the old plant, which is now out of date. The slime plant is being duplicated; on completion its capacity will be 250 tons per day.

Rhodesia Gold Mining and Investment.—This company belongs to the Lewis & Marks group and was formed in 1910 to develop and finance gold-mining properties in Rhodesia. It has large holdings in Lonely Reef and Cam & Motor, works the Huntsman mine, and lets the Bernheim on tribute. It also controlled the Sabi company, but owing to the failure of the property the company

went into liquidation last year. The report for the year 1920 shows that at the Huntsman mine 7,279 tons of ore, averaging 13·8 dwt. per ton, was treated for a yield of 4,043 oz. of gold, the net profit realized being £1,029. The mine continues to develop well on a small scale. At the Bernheim mine the tributers treated 4,991 tons for a yield of 2,539 oz., and the royalty accruing to the company was £1,784. Owing to an accident to the plant the tributers have recently been obliged to cease work, but the company is granting them financial assistance, and work will be resumed shortly. For the five months January to May, 1920, during which the Sabi was in operation 5,700 tons of ore yielded 1,067 oz. The accounts for the year show receipts £19,981 from dividends, chiefly Lonely Reef. Owing to the failure of the Sabi Company a loss on investments of £148,709 was incurred, and the adverse balance for the year was £130,529. There have been other small losses on unsuccessful properties, so it has been decided to reduce the capital of the company from £300,000 to £150,000 by cancelling 10s. of each £1 share.

Rezende Mines.—This company operates gold mines in Rhodesia, and has had a long history of varying fortunes, as recorded already in these columns. Sir Abe Bailey secured control a few years ago, and undertook an active development campaign. Satisfactory dividends have been paid for the years 1918 to 1920. The report for 1920 shows that 66,500 tons of ore was treated for a yield of 29,506 oz. of gold. The income, including premium on gold, was £164,604, and the cost, including taxes and depreciation, was £122,908. The profit was £41,696, and the dividends amounted to £48,000, being at the rate of 40%. The ore reserve is estimated at 140,268 tons, averaging 10 dwt. per ton. All of this is in the eastern section, the central section having been exhausted. The development work on the new seventh level in the eastern section appears to be giving fairly good results.

West Rand Consolidated Mines.—This company belongs to the Albu group, and was formed in 1903 to acquire a number of gold-mining properties in the far west Rand. Other adjoining properties have been acquired since. There are two workings on the Main Reef, and three on the Battery Reef farther south. The operations have not been profitable on the whole, the only dividend having been one of 3¾% paid for 1909. The share capital is £2,004,424, and there are £325,000 debentures. The report for 1920 shows that 396,268 tons of ore was raised, of which 232,688 tons came from the Main Reef and 163,580 tons from the Battery Reef. After sorting, 378,100 tons, averaging 6·27 dwt. per ton, was sent to the mill. The yield of gold by amalgamation was 64,297 oz., and by cyanide 40,878 oz., making a total of 105,175 oz. The revenue from the sale of gold was £572,847, of which about £125,000 represented premium. The working cost was £518,170, leaving a working profit of £54,676, of which £19,749 was paid as debenture interest. The revenue per ton of ore milled was 30s. 3d., and the cost per ton 27s. 5d. The ore reserve is estimated at 1,205,199 tons, averaging 6·5 dwt. per ton. It will be seen that the continuance of working depends on the relative movements of gold premium and costs. A new central pumping plant is being installed, and it will be possible soon to recommence shaft-sinking on the Main Reef.

Roodepoort United Main Reef.—This company belongs to the Albu group, and was formed in 1887 to work gold-mining property in the middle west Rand. Roodepoort Deep was absorbed in 1898, and Roodepoort Gold in 1909. Dividends were paid from 1894 to 1910, but none since. There is at present an accumulated loan of £365,782 owing to the parent company, the General Mining and Finance Corporation. Operations during 1920 could only be continued by adopting a policy of selective mining, and stopping development and shaft-sinking. The report for 1920 shows that 275,016 tons of ore was mined, and 274,200 tons, averaging 4·5 dwt. per ton, was sent to the mill. The yield of gold by amalgamation was 43,030 oz., and by cyanide 14,861 oz., making a total of 57,891 oz. The revenue from the sale of gold was £315,863, of which about £69,000 represented premium. The working cost was £311,770, leaving a working profit of £4,092. The revenue per ton of ore milled was 23s., and the cost per ton 22s. 9d. The reserve is estimated at 249,108 tons, averaging 5·8 dwt. over a width of 41 in. The present position at the mine is critical.

Aurora West United.—This company belongs to the Albu group, and was formed in 1891 to work gold-mining property in the middle west Rand. The property of the Aurora company was absorbed in 1897. The mine was never a financial success, and during the last year or two has only been kept going by means of a policy of selective mining. The report for 1920 shows that 146,192 tons of ore was raised, and after the removal of 10% waste, 131,840 tons, averaging 5·63 dwt. per ton, was sent to the mill. The yield of gold by amalgamation was 22,819 oz., and by cyanide 11,120 oz., making a total of 33,939 oz. The revenue from the sale of gold was £184,770, of which about £38,000 represented premium. The working cost was £181,184, leaving a working profit of £3,586. The revenue per ton milled was 28s., and the working cost 27s. 6d. The reserve of payable ore was estimated on December 31 at 32,050 tons, averaging 7·3 dwt. over 42 in., but if gold rose to 110s. per oz., a further 80 570 tons could be worked. The outlook for the mine at the present time is serious.

New Unified Main Reef. — This company belongs to the Barnato group, and was formed in 1891 to take over the properties of the Eagle and National gold-mining companies operating in the western part of the Rand. Other properties adjoining have since been acquired. Dividends have been paid since 1908. The report for 1920 shows that 128,500 tons of ore, averaging 5·32 dwt. gold per ton, was raised and sent to the mill. The yield of gold by amalgamation was 20,720 oz., and by cyanide 11,960 oz., making a total of 32,680 oz. The revenue from the sale of gold was £182,766, of which about £43,000 represented premium. The working cost was £141,729, leaving a working profit of £41,036. The revenue per ton milled was 28s 6d., the working cost 22s. 1d., and the working profit 6s. 5d. The shareholders received £37,500, the dividends (Nos. 24 and 25) being at the rate of 5% and 10% respectively. The ore reserve at December 31 was calculated at 83,000 tons, averaging 6·2 dwt. over 46 in. There is also some reclamation ore of uncertain quantity to be mined. It is difficult to say how much longer the mine can be operated without loss.

New Goch.—This company belongs to the Albu group, and was formed, as the George Goch,

in 1887 to work gold mining property in the central Rand. Subsequently other adjoining properties were absorbed. Profits have not been great, and the dividends have totalled only 65%, being distributed for the years 1909 to 1911, and 1915 to 1917. During the past year or two the low assays of the ore, combined with the increasing costs, have made the continuance of operations difficult, and if it had not been for the gold premium the mine would have been closed. The report for 1920 shows that 191,030 tons of ore was raised, and after the removal of waste, 184,450 tons, averaging 4·86 dwt. per ton was sent to the mill. The yield of gold by amalgamation was 25,934 oz., and by cyanide 11,116 oz., making a total of 38,050 oz. In addition 2,704 oz. was recovered from accumulated slime. The revenue from the sale of gold was £222,626, of which about £49,000 accrued from premium. The working cost was £220,208. The revenue per ton was 24s. 2d., and the cost per ton 23s. 10d. The ore reserve at December 31 was calculated at 48,717 tons, averaging 6·9 dwt. over 46 in. If gold sold at 110s. per oz., an additional 56,915 tons, averaging 5 dwt. over 50 in., might be treated. There exists in the mine also much ore in pillars, and in Main Reef in the Leader stopes, but the amount and value of this cannot be estimated.

New Primrose.—This company belongs to the Barnato group, and was formed in 1887 to acquire claims on the outcrop six miles east of Johannesburg. Excellent dividends were paid until the approaching exhaustion of the mine three or four years ago. Since then part of the adjoining May mine was acquired, and, later, part of Glencairn was acquired, in both cases the properties being the remnants left by companies in liquidation. The report for 1920 shows that 225,874 tons of ore was raised, and 232,100 tons, averaging 4·44 dwt. per ton, was sent to the mill. The yield of gold by amalgamation was 32,101 oz., and by cyanide 15,383 oz., making a total of 47,484 oz. The revenue from the sale of gold was £268,104, of which about £66,000 represented premium. The working cost was £236,388, leaving a working profit of £31,715. The revenue per ton was 23s. 1d., the working cost 20s. 4d., and the working profit 2s. 9d. The shareholders received £16,250, the dividend (No. 51) being at the rate of 5%. The actual proved ore reserve in the Primrose is very small, being estimated on December 31 at 26,500 tons, averaging 7·6 dwt. over 54 in. Much ore remains, however, in various parts of the mine, and also in the May and Glencairn, and it is possible that operations will continue for another year or two, provided economic conditions allow.

Dundee Coal. — This company has operated coal deposits in the northern part of Natal for nearly thirty years. The report for 1920 shows that the output of the Burnside collieries was 212,795 tons, and of the St. George's colliery 104,480 tons, making a total of 317,275 tons, an increase of 14,599 tons as compared with the previous year. The receipts from the sale of coal and coke were £590,885, and the net profit was £33,835, out of which £33,577 was distributed in dividends (Nos. 40 and 41). The company has some excellent export contracts.

Glencoe (Natal) Collieries. — This company has worked coal deposits in the Dundee district, Natal, since 1902. Two years ago there was a setback owing to floods and influenza epidemic. The report for 1920 shows that a recovery has been made in output, and that profits are once more being earned. But for the shortage of railway trucks the output would have increased further. The amount of coal produced was 104,031 tons, as compared with 96,514 tons in 1919, and 186,800 tons in 1916. The amounts show a net profit of £17,153, out of which £5,354 was written off for depreciation, and £9,375 paid as dividend (No. 19), being at the rate of 3¾%. The manager remarks that the quality of native labour now obtainable is very poor.

New Brunswick Gas and Oilfields.—This company operates gas and oil lands in New Brunswick, Canada. The report for the year 1920 shows that the profit from the sale of gas was £26,101, and from oil £4,886. Other items brought the net income to £39,540. After allowance for taxes and depreciation, the net profit was £7,779. The dividends were at the rate of 6% on the preference shares, and 10% on the ordinary shares, less income tax in both cases. During the year a new oil well, No. 54, was drilled in the Stony Creek field to a depth of 2,745 ft., and it is now the most productive well. No. 53 was started, but owing to the hard rock encountered, drilling was suspended for a time. It is hoped to resume some time during the current year. Three of the producing gas-wells were deepened, and thereby additional flows of gas were obtained. The properties are on offer to the D'Arcy Exploration Co., acting on behalf of the Anglo-Persian Oil Co. During 1920 the D'Arcy Company had three drilling crews at work, and further drilling is to be done during 1921.

Apex (Trinidad) Oilfields.—This company was formed in 1919 to acquire oil-rights in the Fyzabad district, Trinidad. The Anglo-French Exploration Co. and the British-Borneo Petroleum Syndicate, are largely interested. G. R. Airth and Walter Maclachlan are the managing directors. The original capital was £200,000, and this was increased to £400,000 in May, 1920. Three heavy rotary drilling plants have been put to work, and the programme for the period to September 30 of this year provides for the drilling of eleven wells. Wells No. 1 and 2 have been producing regularly; No. 1 is to be deepened to the lower oil-sands; production at No. 2 is impeded by faulty tubing. No. 3 came in on November 6 last, and gave an initial flow of about 100,000 barrels in a few hours. The flow was then checked by the well sanding up. This big flow was far greater than expected, and the dam, which was constructed for the storage of only 50,000 barrels, gave way and the oil was lost. The well has since been brought in again, and the production to the end of April other than that lost amounts to 64,769 barrels. Well No. 4 has been capped to control the heavy gas pressure; it is to be drilled into the lower oil-sands. At No. 5 the 10 in. casing has been set and cemented at 1,050 ft. preparatory to drilling into the oil-sands. No. 6, adjoining No. 4, has been drilled into the upper oil-sands; the production from May 23 to the end of April was 20 150 barrels. At No 7 the drilling rig is in course of erection. The total production to the end of April has been 94,006 barrels, equal approximately to 13,400 tons. An arrangement has been made for the sale of the oil production to Trinidad Leaseholds, Ltd., and 80,000 barrels had been delivered at the time of writing the report, May 7. A geological examination of the company's property was made during the latter half of last year by Dr. F. C. P. Mueller-Carlson, and the directors state that his report is of a most satisfactory nature

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EXPLANATORY NOTE.—Items in italics are names of books reviewed; illustrated articles are denoted by asterisks (*); the letters (*m.d.*) refer to notices of articles under the heading "Mining Digest."

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EDITORIAL

THE ceremony of presenting Sir Robert Hadfield with the John Fritz medal was one of unusual and pleasant significance. It was kindly thoughtfulness that prompted the American societies to instruct their members attending the Engineering Conference held in London last month to form a delegation for making a public presentation of this medal. The John Fritz Foundation was started in 1902 to commemorate the great services to iron and steel metallurgy rendered by the late John Fritz, head of the Bethlehem works in Pennsylvania, and the bestowal of the medal is the highest honour that can come to an engineer from America. Sir Robert, in reply, accepted the medal not entirely as a recognition of his own personal work, but also as conveying an expression of the regard felt by the American engineering profession for the abilities displayed by the British engineers and metallurgists during the war.

REFERENCE is made in the preceding paragraph to the Engineering Conference held in London last month. This was arranged by the Institution of Civil Engineers, and was the first held since the outbreak of the great war. One of the sections was devoted to mining and metallurgy, and here a number of interesting discussions took place. Dr. J. W. Evans dealt with the application of water-power in the development of mineral resources; Mr. R. Nelson described recent improvements in coal cleaning, instancing the action of flotation and table concentrators; Mr. H. Standish Ball read a communication on the Francois cementation process; and Mr. Thomas Crook, of the Imperial Mineral Resources Bureau, presented a paper on the effect of the war on mineral supplies. While these papers did not contain any new material, they served to draw public attention to the present problems in mining and metallurgy, and to demonstrate that mining is an important branch of engineering.

THE collapse of Farrow's Bank and the sentence of Mr. Farrow to four years' penal servitude for the issue of falsified balance-sheets are so much matters of public notoriety that little need be said here. It is to be regretted that a man of such long experience of the iniquities of moneylenders, both regular and irregular, should have attempted to conduct a bank without full experience of the details and without a financial backing that would bring profitable business for the funds deposited with him. While being sorry for the people who lost their money, we are equally sorry that Mr. Farrow did not succeed in his ambition. No doubt the big banks are glad that he has disappeared. At the time of his arrest they advertised extensively that they provided every facility for small depositors, but experience shows that they do not really care for this class of business. The Post Office still gives $2\frac{1}{2}\%$ per year on deposits, and has removed the yearly and total limits in order to attract as much money as possible for public use. The Savings Certificates offer a higher rate of interest than the Savings Bank, but the Post Office limit holds good here. A day may arrive when the Government and the bankers will treat the meanest depositor rather more graciously. Until then there will be a succession of attempts, by honest or dishonest men, to attract the savings of comparatively poor people by offering the advantages enjoyed by their more fortunate fellow-citizens.

ONE or two doubtful projects have been launched publicly or privately during the last few weeks. One revives an old scheme for selling a mixture of chalk and some unspecified ingredient as a substitute for coal. This proposal usually makes its appearance when coal is scarce, whether the scarcity is due to war, railway trouble, or closing of the coal-mines. It seems hardly necessary to refer to this matter here, for no reader of the MAGAZINE is likely to be deluded by the advertisement. Another doubtful scheme deals with a copper deposit in the Shetland Islands. A news agency circulated a paragraph in the daily press announcing the discovery of two copper lodes at Sandwick in the island of Yell, estimated to contain 100,000 tons and 300,000 tons of ore respectively. The secretary of the company wrote to the papers subsequently stating that the deposits are not in Yell but in the Mainland, and modifying the estimate of ore, the implication being that the puffers of the shares "yelled" too soon or too loudly. Many letters have been received by us with regard to this project. Our advice in return has been that inquiries should be addressed to Dr. J. S. Flett, head of the Geological Survey,

at the Jermyn Street Museum. He has an intimate personal acquaintance with the Shetland Islands and their geology. It would be a good chance for a Government Department to enter into financial affairs and tell prospective investors what to expect. As for ourselves we are tired of running the risk of libel actions. It is best that public bodies should take action, as the Surrey County Council did in the case where lemonade " made from Messina lemons " was proved to consist of sugar and phosphoric acid. Even here there were plenty of first-class scientific experts who were prepared to say that the description was justifiable. The MAGAZINE cannot afford either lawyers' fees or the fees of experts practising in the courts.

FATE follows the American Institute of Mining and Metallurgical Engineers. Another so-called crisis has arisen through the resignation of Mr. Bradley Stoughton as secretary. For many years the Institute flourished under the autocratic and beneficent rule of Dr. R. W. Raymond, and under his auspices it became an unrivalled expositor of mining and metallurgical practice. The papers and transactions, through his influence, were of the highest order from both the professional and the literary standpoint, and membership of the Institute was prized accordingly. Before he died the control was wrested from his hands, and subsequently also many modifications in the policy of the Institute were introduced. Of recent years far too many papers have been written and published, and the net for membership has been cast far and wide, without any desire for increased *esprit de corps*, but merely prompted by a desire to increase the revenue of the Institute. The discontinuance of the distribution of papers by means of the monthly bulletin, and the establishment instead of a gossipy monthly paper called *Mining and Metallurgy* was another false step intended for greater publicity and income. We understand that the future of this monthly paper is under serious discussion by the council of the Institute, and that proposals are being considered for its amalgamation with another organ of the profession. In the meantime the reason for Mr. Stoughton's resignation remains a mystery. He says that a secretary should not in any case retain his office for more than ten years, but the wisdom of this view we take leave to doubt. Mr. Stoughton is a capable metallurgist, he is a good tactician and administrator, and he has a sense of humour, and as far as politeness and consideration for others is concerned he is perhaps too polite to some of those with whom he has to come in contact. It is really a pity that he is resigning, and that the council of the Institute cannot adopt a more stable and professional policy.

Statistical Returns

In the last issue we referred to the report by Mr. Hugh F. Marriott on the work at the mines of the Central Mining and Investment Corporation, mentioning that his figures of revenue from the gold output are based on its par value, and that the credits due to the premium are given separately. But for the fact that some other engineers and companies do not adopt this practice, the method would seem to be the obviously and indisputably correct one. The standardization of statistical returns has been referred to in these pages on several occasions, and in many cases improvements in their presentment have been observable during the past few years, but there is still a lack of an agreed system among the mining companies, with the result that the labours of the statistician are unnecessarily complicated. The present is a convenient opportunity for mentioning the matter again, and for glancing through the returns as supplied month by month by the chief companies in various parts of the world.

Taking first the gold mines of the Transvaal, we find that the Central Mining-Rand Mines group report the fine ounces, the estimated value including premium, and the estimated profit on the same terms. The Consolidated Mines Selection, Consolidated Gold Fields, Union Corporation, Anglo-French, Witwatersrand Deep, and Luipaard's Vlei follow the same course. On the other hand, Johannesburg Consolidated and the Albu group do not give the ounces, but report the estimated revenue and profit including premium. They, however, give the estimated price of gold per ton, as do the other groups, so that anyone desirous of finding the figure for the actual output can do so. But it would be simpler for everybody if the figures for the ounces were given, because these are the first obtained when the gold is won, and, anyway, dividing backward does not necessarily give the identical figures. Moreover, uncertainty may exist as to whether the cost of realization has been deducted from the gross revenue or not. In the list of Rhodesian producers, most of the

mines report in ounces, two report in pounds at par, one in pounds at an estimated price of gold, while another does not say whether the pounds represent par value or include premium. In West Africans, Taquah, Abosso, and Ashanti Goldfields report in ounces, Abbontiakoon and Prestea Block A in pounds at par, and Obbuassi in revenue including premium, but without stating the price of gold used in making the estimate. The Indian gold mines give the outputs in fine ounces. The Australasian mines pursue every possible variety of practice. Some give their returns in fine ounces, some in revenue at par, some include specified premiums, and others unspecified premiums; some lump royalties from tributers in one sum with the output from the companies' mines, and these outputs may be at par or may include premium; finally the New Zealand mines give their returns in four-weekly periods and not by the calendar month.

There are a number of other gold mines in various parts of the world under English control or of interest to English shareholders, and most of them report in ounces or in United States dollars. For instance, St. John del Rey gives the par value in pounds and Ouro Preto the ounces, nothing being said of premium in the monthly reports. Plymouth Consolidated and Tomboy, being in the United States, have no premium to help them, so report at par value. Of the Mexican mines, El Oro and Mexico of El Oro report the realized value in United States dollars, and Esperanza and Santa Gertrudis report the profit in United States dollars. The Pato and Nechi companies, operating in Colombia, publish returns of dredging runs of irregular numbers of days in United States dollars. Here, as with the Mexican mines, the gold values are at par, for the companies are not allowed to take advantage of the free markets.

No doubt some companies, in reporting output and profits, prefer to give the full income including premium, so as to make the returns as big as possible; indeed, if the premium were not included a loss would sometimes be shown, and an unpleasant jar would be given to the shareholders. It is naturally argued that from the shareholders' point of view the actual income is what matters. But to the serious student of mining more precise and complete information is necessary, and as its preparation and publication would entail no further time or expense to the several companies, there is no reason why in every case the specific figures for the output should not be given in addition to the revenue derived therefrom.

The Sir John Cass Institute

The delivery of lectures on various aspects of the zinc industry by Messrs. J. C. Moulden and E. A. Smith at the Sir John Cass Technical Institute, to which reference was made last month, has served to draw attention once more to an educational institution in the City of London that deserves to be better known in mining circles than it appears to be. Owing to so many inquiries having been received as to its scope and functions, it is appropriate that something should be said on the subject in these columns.

Sir John Cass was a merchant and alderman of the City of London who flourished about two hundred years ago. He did much for education in his lifetime, and after his death his estate carried on the work. In 1895 a new scheme was put forward by the Charity Commissioners, which provided for the establishment of the present institute. The foundation stone was laid by Bishop Creighton in 1899, and the building was opened by the late Lord Avebury, better known as Sir John Lubbock, in 1902. The institute is in Jewry Street, Aldgate, not far from Fenchurch Street Station. Instruction is given in pure and applied science, and in the arts and crafts. The department of science includes courses in mathematics, physics, chemistry, and metallurgy, and the curriculum is designed to meet the requirements of students who are engaged in the chemical, metallurgical, electrical, and engineering industries. The institute is intended primarily for the evening student, who is occupied in earning his living during the day, but facilities are also afforded for special research work during the afternoons. The fact that the classes are held only in the evenings makes it possible for the institute to enrol among its teachers a number of practical men who have won distinction in their own particular lines, and who, from a sense of duty, are ready to give of their best to those desirous of acquiring knowledge. The head of the institute is Dr. Charles A. Keane, who is well known for his books on chemistry and analysis, some of which he wrote in collaboration with Dr. George Lunge. In the department of metallurgy, the first lecturer was Dr. Guy Bengough, who is known for his researches on corrosion. He

was followed by Mr. C. O. Bannister, who was associated with the firm of Edward Riley & Harbord, and is now professor of metallurgy in the University of Liverpool. Mr. George Patchin, A.R.S.M., M.Inst.M.M., became head of this department of the institute in 1919. He had previously achieved great success as a teacher at the Birkbeck College. Among other members of the present staff the following may be mentioned: Mr. W. A. C. Newman, assistant chemist at the Royal Mint; Dr. O. F. Hudson, metallurgist at the Admiralty research department; and Dr. W. R. Schoeller, chemist to Daniel C. Griffith & Co., who takes the class on mineralogy. In addition to the regular course, special lectures are given every year, Last year three lectures were delivered by Mr. H. Livingstone Sulman, on "Froth Flotation." This year, as already mentioned, Mr. J. C. Moulden is lecturing on "Modern Developments in the Zinc Industry," and Mr. E. A. Smith is lecturing on "Industrial Applications of Zinc." These special lectures are open to outsiders, and many City men have found them helpful and instructive.

The metallurgical course includes a variety of subjects, as will be seen from the following list: General metallurgy, elementary, intermediate, and advanced; assaying; iron and steel; metallography; mechanical testing of metals and alloys; heat treatment of metals and alloys; foundry practice; mineralogy; mechanical drawing for metallurgists; materials of construction and design. These courses include lecture, demonstration, and laboratory work wherever suitable. Additional courses are being considered, to deal with furnace design and construction, and with electric furnaces and smelting. The complete curriculum extends over four years, not including a preliminary year devoted to elementary physics and chemistry, and at the end of that period a diploma is granted to those students who reach the required standard. Other departments of the institute are organized on the same scale, and some of the subjects dealt with are of interest to metallurgists: for instance, Dr. Owen's course on colloids.

In addition to lecture rooms and drawing office, the metallurgical department contains a main laboratory for general analysis, a laboratory for dry assaying and furnace work, a metallography and pyrometry room, a mechanical testing laboratory, and a moulding and casting room for foundry work. The laboratories are well equipped and arranged in the latest manner. The metallography and pyrometry room contains photomicrographic outfits, polishing machines, visual microscopes, galvanometers and millivoltmeters, thermo-couples, resistance pyrometers, differential apparatus and electric furnaces for ascertaining critical temperatures, thread recorder, Callendar recorder, and dark room. The mechanical testing laboratory, which was endowed by the Goldsmiths' Company in 1914, is equipped with a 30 ton Buckton testing machine fitted with autographic recorder, an Izod impact testing machine, a Brinell hardness machine with Ludwick cone attachment, a Sankey bending machine, a Shore scleroscope, and a cement testing plant.

The institute achieves success and supplies instruction which is greatly appreciated by a great variety of students. The further expansion of the sphere of usefulness of the metallurgical department is the ambition of Mr. Patchin, and we trust the profession will give him encouragement and back his efforts in a practical way.

St. John del Rey

As usual, Mr. George Chalmers' yearly review of operations and conditions at the Morro Velho gold mine in Brazil, operated by the St. John del Rey Mining Company, is replete with interest. Few companies or managers give such elaborate details of their work. There is no suppression of the difficult problems, and the reasons for deciding on any particular policy are fully disclosed and candidly discussed. And there have been, and still are, many difficult problems. For instance, the ore is arsenical and not amenable to what may be considered standard treatment. The ore and walls do not stand well, so driving and sinking must be done off the lode, incline shafts are not desirable, and close filling after stoping is necessary. The ore-body is in the nature of a narrow elongated pipe pitching in a vertical plane, so that prospecting for it at depth by diamond drill from the surface is quite out of the question. As for sinking a deep-level vertical shaft, it happens that at the period when such a policy might have been adopted with success, in the light of subsequent knowledge, the ore was showing signs of becoming poorer in depth, and any policy other than following the lode would have been financially unsound. Thus we have the series of vertical shafts and connecting tunnels characteristic of St. John

del Rey, which are so inexplicable to those who have not read Mr. Chalmers' reports since he took up the management thirty years ago.

The problems that have faced Mr. Chalmers during the last few years have arisen from two causes, first the flattening of the pitch, and second the unbearable heat at the bottom workings. As regards the pitch, this was approximately 45° at a vertical depth of 3,000 ft. As the workings went down, the pitch has gradually tended to flatten, and at 5,500 ft. the ore-body is at about 30° with the horizontal. This alteration, of course, makes the successive tunnels longer, so that below the 22nd horizon, 6,126 ft. vertically below the outcrop, there will be no alternative but to sink incline shafts to follow the pitch. At the present time the deepest development work is at this horizon. At first the ore exposed proved somewhat disappointing, but it was felt that it was just possible that the main ore-body had not been struck, that the flattening had been greater than calculated, and consequently that parts of the lode unpayable in the upper levels had been intersected by the tunnel and winze. This uncertainty existed when the annual report was circulated. At the meeting of shareholders the Chairman had the great good fortune to be able to announce that the true lode had been discovered in a cross-cut and that the gold assays are as good as ever.

The other present difficulty to which reference is made arises from the heat at depth. This question has received the close attention of Mr. Chalmers for the last ten years, and has formed an important feature of his yearly reports for some time past. The whole matter is crucial to the future of the mining industry in all parts of the world, and the experience at this mine should be discussed in conjunction with such cases as the City Deep. In 1913 Mr. Eric Davis, one of the staff at St. John del Rey, commenced a study of temperatures with the dry-bulb and wet-bulb thermometers. By experience it was decided that the wet-bulb temperature in the stopes should not be greater than 82° F., and it was calculated that to get these conditions the initial moisture content of the air entering the mine should be not more than about 50 grains per pound of dry air. This content corresponds to a saturated condition at 45° F. A refrigerating plant was then ordered, capable of cooling 80,000 cu. ft. of air per minute to a temperature of 43° F. It is not necessary here to go into details of this plant, for particulars were given in the MAGAZINE for October, 1919. This plant would have been erected long ago if it had not been for the war. The delays in delivery were unavoidable under the circumstances, but they caused great anxiety at the mine. Eventually the machinery and outfit arrived last year, and the plant was started at the beginning of December. In the meantime, however, the development of the mine in depth became almost impossible, and the stoping operations became difficult. The workmen could not stand the heat, and many of them left, with the consequence that the output was reduced. The most serious difficulty arose in connexion with the driving of the tunnel on the 22nd horizon, and the sinking of winze No. 31 from the horizon above to meet it. The conditions of working may be gleaned from the fact that the rock temperature in these dead ends was 117° F. The heat was sufficient to interfere with the electric motors driving the fans, and altogether there was some doubt whether the human being could achieve the connexion of tunnel and winze. Mr. Chalmers rightly praises Captain Watts and his helpers for persisting in the driving of the tunnel under these adverse circumstances. The connexion was eventually made on January 2; and the circulating current was then established. As the cooling plant had been started a short time before there was no difficulty in continuing the work and developing the ore-body at this depth. It is clear, however, that if the cooling plant had not arrived in time there would have been no alternative but to stop development in depth and realize the ore reserves. As it is, the cooling plant makes it possible to apply the winding and other machinery already provided for sinking and working to a vertical depth of 7,500 ft. In connexion with this brief notice, it is desirable to read the precis of the last yearly report, printed on another page, which is accompanied by a drawing showing the bottom workings. Owing to the small size of our page it is not possible to reproduce the full plans and elevations accompanying the report. Those of our readers who are interested should write to the company for a copy of the report, or call on the ever-obliging Mr. Kup, the managing director, and inspect the model of the ore-body and the various elaborate working drawings showing the form of the ore-body and the method of development and mining.

REVIEW OF MINING

Introduction.—The settlement of the coal dispute has come at last, and the mines are gradually resuming operations. The steel makers and the engineering works are hoping that coal will be plentiful and reasonably cheap. If such hopes are verified, the consumption of metals will once more be revived, and the producers of copper, lead, tin, and zinc will benefit.

Transvaal.—The dividends declared on the Rand for the half-year January to June are given in the accompanying table. The figures are lower than those for the previous half-year, but as the last-named figures were rather greater than might have been expected, the market was quite prepared for the fall.

	2nd half, 1919.	1st half, 1920.	2nd half, 1920.	1st half, 1921.
	s. d.	s. d.	s. d.	s. d.
Brakpan	3 0	2 0	6 0	3 0
City Deep	2 9	2 6	4 0	4 0
Consolidated Langlaagte	1 6	1 0	1 6	1 0
Consolidated Main Reef	1 3	1 3	1 9	9
Crown Mines (10s.)	3 6	2 9	5 0	1 0
Ferreira Deep	1 0	2 0	2 6	1 6
Geduld	*a*	1 6	2 0	1 6
Geldenhuis Deep	1 6	6	2 6	—
Government Areas	4 0	4 0	6 0	5 0
Kleinfontein	—	—	1 0	—
Knight Central	—	—	1 6	—
Knights Deep	9	—	—	—
Langlaagte Estate	1 6	1 0	1 6	1 0
Meyer & Charlton	14 0	10 0	14 0	10 0
Modderfontein (10s.)	30 0†	4 6	5 9	4 3
Modderfontein B (5s.)	9 6**	6 6**	2 6	2 0
Modderfontein Deep 5s.	3 3	3 0	4 3	3 3
New Primrose	1 0	—	1 0	1 0
New Unified	1 0	1 0	2 0	1 0
Nourse Mines	9	9	1 0	6
Robinson Deep "A" (1s.)	—	2 0	—	—
Robinson Gold (£5)	2 6	1 0	2 0	1 0
Rose Deep	3 6	2 0	3 6	1 6
Simmer & Jack	6	—	6	—
Springs Mines	—	1 0	3 0	1 6
Sub-Nigel	1 0	1 0	1 6	9
Van Ryn	1 6*	1 6*	1 6*	1 6*
Van Ryn Deep	5 9‡	5 0	8 0	6 0
Village Deep	1 3	6	1 6	9
Witwatersrand Gold	1 0	1 0	3 0	2 0
Witwatersrand Deep	—	—	—	1 0
Wolhuter	6	1 3	1 3	9

† On old £1 shares. *a* Scrip distribution equal to 16%. *Free of tax. ‡Also Scrip. **On old £1 shares.

The total dividends of Transvaal gold mining companies declared during the half-year were £3,238,838, of which £2,260,222 came from companies operating in the Far East Rand, and £978,616 from the older parts of the Rand. The dividends declared by companies outside the Rand were £37,563.

Last month we quoted Mr. H. F. Marriott's report on the conditions at the mines of the Central Mining-Rand Mines group. One of his points as regards efficiency related to the obsolete law that natives must not start work each day before the white overseers give instructions, and that they must leave in front of the white man. He pointed out that under this regime the actual working time of the native averaged only five out of the statutory eight hours. It is now announced that the Mines Department is embodying in the regulations a clause giving permission for the establishment of night inspection shifts with the object of enabling the natives to start work earlier. Evidently Mr. Marriott's protest has borne fruit.

The sinking of No. 2 shaft at West Springs is to be suspended for a time and the ground below is to be explored by bore-hole. The reason for the suspension is not given, but presumably the water trouble referred to in the yearly report is the cause. In the meantime development from No. 1 shaft is to be intensively pushed and connexion made with the workings started from Springs mine, so that an ore reserve may be created at the earliest possible date.

At Springs mine the ore reserve has been substantially augmented recently, and the directors have decided to purchase additional plant so as to increase the monthly tonnage from 40,000 to 50,000.

The No. 7 shaft at Geduld reached the reef at a depth of 2,450 ft. on June 19. The assay-value was 0·6 dwt. over 35 in. Though this figure is low, it does not worry the company, because it happens that an extensive area of unusually high-grade ore has already been developed in the neighbourhood of the shaft. In the yearly report recently issued it was stated that development in this area had proved 4,215 ft. in ore, of which 66% was payable, averaging 16 dwt. over an estimated stoping width of 66 inches.

Rhodesia.—The output of gold during May was 48,744 oz., as compared with 47,858 oz. in April and 46,266 oz. in May of last year. The value is reported at £225,841, as against £282,396 in April, the divergence being due to the usual erratic manner in which the premium is credited in Rhodesia. Other outputs during May were: Silver, 12,806 oz.; coal, 44,688 tons; chrome ore, 5,700 tons; copper 266 tons; asbestos, 2,345 tons; arsenic, 8 tons; mica, 6 tons; diamonds, 8 carats.

During 1920 the ore milled at Shamva amounted to 609,509 tons, and the yield of gold was 96,718 oz. The assay value of the

ore was 3·6 dwt. per ton, of which 3·26 dwt. was extracted. The gold sold for £538,887, and the working profit was £223,526, out of which £180,000 was distributed as dividend, being at the rate of 30%. The reserve is estimated at 1,981,250 tons, averaging 4·1 dwt., as compared with 1,982,000 tons averaging 4·31 dwt. the year before. Eight additional Nissen stamps and one tube-mill have been erected during the year. With regard to the general mining policy, Mr. Cyril E. Parsons, the consulting engineer, says that the future of the property and the prolongation of its life still depend largely on the possibility of profitably removing and treating the large tonnage of low-grade overburden, so that the better ground lying underneath can be successfully mined; any attempt to mine without removing the overburden would in his opinion cause disastrous falls of ground.

In speaking at the meeting of Fanti Consolidated, as reported in the MAGAZINE last month, Mr. Edmund Davis announced the sale of the chrome interests. He stated that the new discoveries of ore in Rhodesia and competition from other parts of the world would lead to diminished profits. Thus the control of the chrome market, so long associated with Mr. Davis's name, comes to an end. The deposits discovered two years or more ago in Rhodesia are very extensive. They are being developed by Rhodesia Base Metals, Ltd.

Nigeria.—The Bisichi Company has received advice from its engineer to the effect that prospecting operations on one of the leases have given excellent results, four million cubic yards of ground being proved to contain approximately 5,000 tons of cassiterite. The whole of the area has not yet been tested, and it is believed that further prospecting will continue to increase the reserve.

The Nigerian Consolidated Mines was formed early in 1920 to acquire a number of tin properties in the Rayfield, Jemaa, and Womba districts from Mr. W. E. Thomas, who became managing director. As recorded in our issue of April, Mr. Thomas died suddenly of pneumonia. The report for the period from the registration of the company to February 28 shows that the output of tin concentrate was 233 tons, which was satisfactory considering that the properties had not been brought into full working order. The accounts show credits of £24,308 from the sale of concentrate, but the year ended with an adverse balance of £3,843. Owing to the fall in the price of tin, operations have been discontinued for a time, though some tributing is being done. The directors write hopefully of the prospects of increasing the output when conditions improve.

Australia.—The Australian Court having consented to a suspension of the award of higher wages and a modification of the working hours, the Mount Lyell company finds it possible to continue work. The Wallaroo and Moonta company announces the approaching resumption of operations on a restricted scale. At Mount Morgan the conferences between the directors and the leaders of the trades unions have brought no result so far, and the mine remains closed.

The Great Boulder Proprietary Company has paid a handsome dividend for 1920, but the profits were largely due to the gold premium. The working cost was 41s. 9d. per long ton, as compared with 35s. 8d. in 1919, and 32s. 6d. in 1918. Six years ago the cost was about 24s. per ton. The new property at Norseman has given good results, and substantial profits are expected, providing labour conditions are satisfactory.

Siam.—The Siamese Tin Syndicate made a record in connexion with output during 1920. The three dredges treated 2,200,640 cu. yd., and extracted 937 tons of tin concentrate, the previous highest figures having been in 1916. The income from the sale of concentrate was £198,285, and the working profit £45,271, out of which £36,000 has been distributed as dividends, being at the rate of 30%. It will be remembered that the company floated a subsidiary eighteen months ago, called the Bangrin Tin Dredging Company, to deal with alluvial tin ground about five miles north of the company's property. Rails have since been laid and the site for the dredge has been prepared. The dredge has been designed by Messrs. F. W. & R. Payne, but its construction has been delayed by labour troubles in this country, and by the coal strike.

Burma.—The issue of new preference shares by the Burmah Oil Company, to which reference was made last month, proved a great success. Since then the report for 1920 has been issued. The gross profit was £4,891,500, out of which £1,153,800 was written off for depreciation, while the excess profits duty is estimated at £1,900,000. The ordinary shares received £1,543,000 as dividend, being at the rate of 30%. The present company was formed in 1902 as

an expansion of a company of the same name registered in 1886. The chief property is in the Yenangyaung oilfield in the Irrawady valley, and there is every expectation that the ground will continue to yield handsomely for many years yet. A pipe-line 300 miles long takes the crude oil to Rangoon, where refining is done. The company formed the Anglo-Persian Oil Company, and, with the British Government, still holds nearly all the ordinary capital of that company. It purchased the control of the Assam Oil Company, and it operates the property of the Budderpore Oil Company, also in Assam. Among other interests are shareholdings in the United British Oilfields of Trinidad, and a participation, in association with the Anglo-Persian, in exploratory operations in Hungary. In order to obtain material for receptacles for its various products, the company recently joined with the Tata Iron and Steel Co., Ltd., in promoting the Tinplate Company of India, and the works are now in course of erection at Jamshedpur. Electric power plant has been installed on the company's properties in the Yenangyaung oilfield, and power will also be supplied to its neighbours, the British Burmah and the Indo-Burmah Petroleum Company.

In the May issue some particulars were given of a private and informal meeting of shareholders in the Burma Corporation, at which a resolution was passed agreeing to the company purchasing the control of a group of lead manufacturers in this country. Subsequently powerful protests were made by influential shareholders. It has since been announced that these protests have carried weight, and that it has been decided not to proceed with the matter. There is no inherent reason why the proposal should not be a sound one commercially, providing the facts and details are all right ; but the attempt to rush the matter semi-secretly raised the opposition. The way in which the control of Burma Corporation is exercised leaves much to be desired.

Cornwall.—As reported last month, an extensive fall of ground has occurred in the main shaft at East Pool. The cables were broken, so that the electric pumps were put out of action. The old Cornish pump at Agar shaft has not been able to cope with the water. The position thus became serious, not only to East Pool, but to the adjoining mine, South Crofty. The directors and engineers of the two mines have met several times, with a view to devising some joint action. The engineers, Mr. M. T. Taylor and Mr. Josiah Paull, are now engaged in considering methods for combating the water.

Canada.—The Chairman of the Mining Corporation of Canada, at the recent meeting of shareholders, referred to the acquisition of a majority interest in the Flin-Flon copper-gold property in Manitoba. He stated that 16,000,000 tons of ore had been proved, with an additional probable 9,000,000 tons. He also claimed that the sampling of recent workings showed a content 30% higher than previous figures. Details of these new estimates are desirable before they are likely to arouse much interest among mining men.

United States.—A proposed new mining law is to be submitted to Congress. It has been drawn up by the aid of the mining societies and the Bureau of Mines, and the committee has had the advice of mining lawyers. A notable feature of the proposal is the abolition of the " apex law " as far as mining claims recorded in the future are concerned. Another feature is the discarding of the principle of actual discovery of a mineral deposit as a prerequisite to the location of a claim, though it is provided that discovery must be made before a claim is patented.

The suspension of copper production in the United States is well known, but the slackness of the iron and steel trades has not until recently been indicated by the issue of tangible figures. It is now announced that the shipments of iron ore from the Lake Superior mines to the smelters for the five months to May 31 last was 2,770,238 tons, as compared with 7,206,939 tons for the same period during 1920.

Mexico.—The report recently issued in the United States to the effect that the Mexican oilfields would be exhausted in the course of a year or two was not believed in this country, where it was held that the report was written for some political or similar purpose. Another report has since been issued from the same source in which it is stated that the potential production of the Mexican oilfields is almost unlimited. This is probably rather a better guess than the first, but it is equally vague and unsatisfactory.

The political position with regard to Mexican oil, as outlined in the foregoing paragraph, has been publicly exposed by the action of the Standard Oil in threatening to cease production and exports from its

properties in Mexico. The Mexican Government had announced the imposition of a duty on oil exports, anticipating a threatened discriminating import duty into the United States. Some doubt existed as to whether the Mexican Government would enforce this duty. The daily papers allege that the United States Government will take steps to protect the American citizens thrown out of work by the cessation of the Standard Oil's activities. The other oil companies operating in Mexico declare that they are pleased at the Standard Oil's attitude, but it must be remembered that there is a political aspect as between the United States and Mexican Governments, and that the Standard Oil's tactics go further than a mere trading ruse.

Ten years ago the directors of the El Oro Mining and Railway Co. decided to form a local subsidiary company for the purpose of testing other properties in Mexico. This subsidiary has already done much work in the States of Zacatecas, Mexico, Hidalgo, and Jalisco. To provide further funds the El Oro Company has recently subscribed for 50,000 additional shares of 10 pesos each, and is issuing 49,500 shares among shareholders as a bonus dividend, being at the rate of one share for every 25 El Oro shares.

Colombia.—A company has been formed, called the Colombian Proprietary Gold Mines, Ltd., to acquire alluvial gold properties on the Llantin river, a tributary of the Saija, about 70 miles south of the port of Buenaventura. Mr. T. J. Ive is chairman, and Messrs. Inder, Henderson, & Dixon are the consulting engineers, while the British Platinum & Gold Corporation has underwritten the present issue of shares. The vendor company is the Compania Minera de Santa Rosa, of which Mr. Henry J. Eder, of Cali, Colombia, is the largest shareholder. A report has been made by Mr. A. G. Davidson, who has been associated with the consulting engineers for some years. The developments have warranted the placing of a contract with Messrs. Lobnitz & Co., Ltd., of Renfrew, for the construction of a dredge having a capacity of 60,000 cu. yd. per month.

The British Platinum & Gold Corporation has issued a statement showing that since the dredge on the Opogodo property was put to work in December last a total of 966 oz. of platinum, together with 280 oz. of gold, had been recovered up to May 21. A model of this dredge was shown at the Colombian Government's stand at the Rubber and Tropical Products Exhibition at the Agricultural Hall. In this dredge a balanced reciprocating screen is used instead of cylindrical screens for removing coarse stones and boulders.

The report of the Oroville Dredging Company, whose assets are now entirely in the form of shares in companies operating in Colombia, gives a brief account of the performance of the dredges operated by the Pato and Nechi companies during the year ended September 30 last. At the Pato property 1,437,600 cu. yd. yielded gold worth $526,267, or 36·6 cents per yard. The operating cost was 13 71 cents per yard. At Nechi 2,135,084 cu. yd. gave gold worth $816,188, or 38·2 cents per yard. The Oroville received dividends of £88,186 and £28,348 respectively from its holdings in Pato and Nechi, and distributed £94,398 among shareholders, being at the rate of 2s. 9d. per £1 share.

Brazil.—The output of gold from the Ouro Preto mines during 1920 was 27,858 oz., obtained from 82,100 tons of ore. The gold sold for £156,490, and the working profit for the year was £16,229, out of which the 10% dividend on the £29,661 preference shares has already been paid. A further dividend on the preference shares of 5%, and a dividend of 5% on the £39,429 ordinary shares have since been paid. Developments have continued to disclose ore.

Russia.—Mr. Leslie Urquhart delivered one of his characteristic speeches, displaying a thorough knowledge of Russian conditions from both the political and mining point of view, at the meeting of the Russo-Asiatic Consolidated, held on July 6. This company was working and developing many important properties before the revolution, but these properties have been nominally confiscated by the Bolsheviks. One of these days Mr. Urquhart will induce the powers that be to respect the rights of property, to the benefit of Russia and of all those desirous of working and trading within her boundaries.

Spitsbergen.—In May we mentioned that the Northern Exploration Company was offering £150,000 Secured Notes to shareholders with the object of keeping the organization alive. It is now announced that £61,610 of these Notes have been allotted. This has enabled the company to pay off its debts, and to dispatch a small expedition this summer.

THE IRON AND STEEL INDUSTRY OF INDIA

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(*Concluded from page 347, June issue.*)

The Bengal Iron Co., Ltd.—This company was registered in December, 1919, with an authorized capital of £2,500,000 to acquire the Bengal Iron & Steel Co., Ltd. The works are situated at Kulti in Bengal on the East Indian Railway, 142 miles from Calcutta. It has already been shown how the latter company, founded in 1889, was the lineal descendant of the Barakar Iron Works Co., Ltd., which was started in 1875. In 1889 the plant consisted of two small open-top furnaces, only one of which was worked, for which the blast was heated by coal in pipe stoves, and one blowing engine with its complement of boilers which were entirely fired by coal. The production of pig iron in 1889–90 was about 9,000 tons per annum, and was disposed of to Government establishments either in that form or in the shape of castings. The foundries then covered an area of 12,300 sq. ft., and the production from them was 3,800 tons per annum. At that time the company did not own its own collieries, but purchased its coal and coke requirements in the open market. The site of the works was chosen originally on account of the close proximity of both coal and iron ore supplies, and for many years the clay ironstone nodules that formed the ores for the furnaces were obtained from a geological horizon in the Gondwanas, known as the Ironstone Shales. This crops out between the coal-bearing Barakar and Raniganj stages, and stretches for some distance east and west of the works. The iron ore was obtained by contract with the local proprietors of bullock carts, and the supply was uncertain in quantity and variable in quality.

The remodelling of the works was taken in hand at once. The two original blast-furnaces were converted into close-top furnaces to enable the gas to be utilized for firing the boilers. At a later date, as they required rebuilding, they were removed and replaced by two modern furnaces. A new furnace was also erected, fitted with three 17 ft. diameter Cowper stoves. During the period up to 1914 steady progress was made; collieries were purchased and developed, namely, Noonodih, in the Jherria field, in 1905, and Ramnagar, 1½ miles distant from the works, and connected with them by a light railway, in 1907. By 1908 several small iron ore areas had been acquired, one of which was at Kalimati (now Jamshedpur), close to the site of the present Tata iron and steel works. With the opening up of the company's mines at Manharpur, in the Kolhan Estate of Singhbhum, in 1910, a constant supply of first-class hematite was assured, for already many millions of tons of high-grade material have been proved, and the use of the ore from the Ironstone Shales was finally discontinued. The outbreak of the war found three furnaces in operation with an annual output of approximately 80,000 tons of pig-iron, each furnace with its four Cowper hot-blast stoves, and the whole plant operated from a modern power-house containing three turbo-blowing engines of a total horse-power of over 4,000. The plant in existence to-day will now be described.

There are four furnaces in operation, a fifth under construction, and twenty stoves for heating the blast; seventeen of the latter are 65 ft. high by 21 ft. in diameter, and three are 55 ft. high by 17 ft. in diameter. On the completion of the fifth furnace the total capacity of the plant will be 175,000 tons of pig iron per annum. The blast is supplied from turbo-blowers of the Parsons type, with a total capacity of 115,000 cub. ft. of air per minute. There are twenty-four Lancashire boilers, fired by waste furnace gas, in two batteries, supplying steam to the blowing engines. The iron ore, coke, and limestone are delivered from railway wagons and raised to the charging hoppers by two steam and electric hoists. In the case of No. 5 furnace, a Brown Hoisting Co.'s charging apparatus has been provided. The slag is removed in Dewhurst ladles and taken to the tip in a molten state.

The coking plant consists of three batteries each of thirty-four Simon Carves by-product ovens, with an out-turn capacity of 130,000 tons per annum, complete with recovery plant for coal tar and ammonia, and

also a sulphuric acid plant. A fourth battery is under construction which will raise the total output to 200,000 tons per annum. The present raisings of coal from the company's collieries (Khendwa and Ramnagar in the Raniganj field and Noonodih in Jherria) are about 150,000 tons per annum, but are being increased to 250,000 tons. The requirements of the coking plant are drawn from these and other sources. The coal is discharged from railway wagons into hoppers, whence it is elevated to the crushing machines and thence to the storage bunkers. It is compressed before entering the ovens.

The waste heat from the ovens passes to a battery of boilers, where it is used in raising steam for the electric generating plant, which has a capacity of 2,500 kw. and provides power and light throughout the works, to the Ramnagar colliery, and to the pumping station at Monberia on the Barakar River.

The area occupied by the foundries has increased from 12,300 sq. ft. in 1890 to 175,000 sq. ft. to-day. This department comprises pipe foundries, railway sleeper and chair foundry, general casting foundry and brass foundry, together with pattern shops, etc. Pipes are made in dry sand moulds and vertically cast. One plant is fitted with hydraulic and the other with electric power. Flanged pipes of all sizes for steam or water mains are made. During the war the company supplied many miles of pipes for Mesopotamia and the North-West Frontier, in addition to 20,000 tons of high-grade ferro-manganese made from Indian ore and dispatched to America, France, and Italy. Large quantities of railway sleepers were also supplied for extensions in various military zones. The railway sleeper foundry is fitted with moulding machines for making both plate and bowl designs.

In the general foundry all kinds of castings up to 10 tons in weight are manufactured, including columns for buildings and mills, straining posts and sockets for fencing, mortar mills, road rollers and machinery castings, ornamental columns, lamp-posts, railings, etc. The foundries are capable of turning out 60,000 tons of castings per annum divided as follows: pipes 15,000 tons, sleepers and chairs 30,000 tons, general castings 15,000 tons.

The Bengal Iron Co., Ltd., to-day employs about 100 Europeans and 15,000 Indians, and every effort is made to cater for the physical well-being and comfort of both. A modern hospital administers free medical treatment. Foodstuffs are issued at cost price, while schools for boys and girls have been built and are principally financed by the company.

Brands of Indian Pig Iron.—The typical composition of the iron ores and fluxes used by the two companies producing pig iron in India to-day are given in the tables on the opposite page.

Dr. A. McWilliam, in the *Journal of the Iron and Steel Institute*, 1918, pp. 451–68, says of the pig iron produced by the Tata Iron & Steel Company: "The series of pig irons produced contain about 0·4% of phosphorus, and can fairly regularly be kept at less than 0·05% of sulphur with less than 1% silica for making basic open-hearth steel, the manganese being brought up to over 1% by the addition of small quantities of manganese ore to the blast-furnace burden. Nos. 1, 2, 3, and 4 foundry pig irons are also made as required."

Indian pig iron in general compares favourably in quality with the best English and Scotch foundry irons, and the special brands which are made by both the producing concerns are superior to any iron imported into India, with the exception of hematite iron. In this connexion it should be mentioned that there is available in India a small output of high-grade coke that could be used if necessary, in conjunction with special ores, to make hematite pig iron equal to the best brands.

The Mysore Government's Charcoal Iron Works.—The Government of the State of Mysore has a blast-furnace nearing completion at Benkipur, where the iron ores of the Bababudan Hills in the Kadur district will be smelted with charcoal. The timber is to be obtained from the great forests of the Shimoga and Kadur districts, and to be treated in a modern wood-distillation plant at Benkipur. It is proposed to manufacture calcium acetate, wood alcohol, and possibly calcium carbide as by-products. The estimated cost of the works is approximately £630,000. The plant is being constructed by the Tata Iron & Steel Co., Ltd., and the company has also been appointed managing agents for a period of twenty-five years.

The Indian Iron & Steel Co., Ltd.—This company was registered in March, 1918, with an authorized capital of Rs.3,00,00,000, subsequently increased to Rs.3,01,50,000 (£2,010,000). Two blast-furnaces with an estimated output of 110,000 tons of pig iron, or 73,000 tons of ferro-manganese, are being

TATA IRON & STEEL CO.

Gurumaishini Ore.	%	Gangpur Dolomite.	%
Fe	63	CaO ...	30
Mn	0·8	MgO ...	21
S......	0·01	Fe_2O_3...	1
P	0·09	Al_2O_3 ..	0·7
Si	2 to 3	SiO_2 ...	2 to 3

An average coke contains about 0·5% S, 0·22% P, and 20% ash.

BENGAL IRON COMPANY, LIMITED.

Manharpur (Pansira) Ore.	%	Sutna Limestone.	%
Fe_2O_3	92·71	$CaCO_3$	91·80
(64.9% Fe)			
SiO_2	2·10	$MgCO_3$	1·70
Al_2O_3	1·25	SiO_2	5·15
MnO...	0·05	FeO	0·25
CaO	0·15	Fe_2O_3	0·32
P_2O_5	0·11	Al_2O_3	0·54
S............	trace		
Alkalies	,,	H_2O	0·10
Loss on ignition	3·50		—
			99·86

ANALYSES OF PIG IRON EMPLOYED BY THE BENGAL IRON COMPANY, LIMITED.

Brand.	C. (graphite).	C. (combined).	Si.	Mn.	P.	S.
Manharpur	3·00 to 3·50	0·20 to 0·10	2·75 to 3·25	0·20 to 0·25	0·15 to 0·25	0·10 to 0·02
Bengal	3·00 ,, 3·20	0·30 ,, 0·10	2·50 ,, 3·00	0·90 ,, 1·20	0·80 ,, 1·00	0·03 ,, 0·06

put up at Asansol on the Raniganj coalfield. A large part of the plant has arrived at the site and is being erected now. Development work at the company's mines in the Singhbhum district has proved very large ore reserves, and it is stated that over 100,000 tons are already mined. About 5,000 persons are employed at present.

NEW IRON AND STEEL WORKS.—The establishment of two new iron and steel works in India has passed the stage of consideration, and though it is not permissible at this juncture to give any details about them, it may be stated that very large iron ore reserves have been developed on the concessions granted to the promoters, and supplies of coking coal are assured. Both these raw materials come from the same districts as those drawn upon by the existing companies. The new works may be located as Chandil on the Bengal–Nagpur line between Sini and Adra, and at Manharpur, respectively.

SUBSIDIARY INDUSTRIES.—A great deal of the new plant now under erection at the Tata Iron & Steel Works is intended to supply semi-finished steel to subsidiary industries which are now commencing to grow up at Jamshedpur and other places in India. Among these the following may be mentioned :—

(i) Galvanized Iron. It is anticipated that the production of sheets for this purpose will have commenced within the next twelve months, and in the meantime the smelter of the Indian Zinc Co., Ltd., with a capacity of 10,500 tons of spelter and 25,000 tons of sulphuric acid per annum, is being built. The concentrates for the smelter will be obtained from the Bawdwin mines of the Burma Corporation, Ltd. The potential market for galvanized sheets in India may be judged from the fact that in the fiscal year ending 1914, the imports of these articles into the country amounted to 277,595 tons, valued at £3,584,957.

PRODUCTION OF PIG IRON, FERRO-MANGANESE, AND STEEL IN INDIA (in long tons).

	Pig Iron.	Ferro-Manganese.	Steel.
1916	244,710	1,843	131,292
1917	248,132	1,475	162,711
1918	248,018	13,223	182,269
1919	307,374	2,650	186,901
1920	317,639	1,183	156,240

(ii) Tinplate. The Tinplate Co. of India, Ltd., has been formed to take up the manufacture of this article in India, and the necessary bars or sheets will be purchased from the Tata Company. The Burma Oil Co., Ltd., alone is said to require some 50,000 tons of tinplate per annum for the containers in which some of its products are marketed.

(iii) Cables. The reduction works of the Cape Copper Co., Ltd., which are capable at present of producing 250 tons of copper per month, are only 15 miles from Jamshedpur. It is proposed to establish a cable company which will make use of steel wire from the Tata mills and copper from the Rakha Hills smelter for this purpose.

(iv) Refractories. Reference has already been made to the Kumardhubi Silica & Firebrick Co., Ltd., in which the Tata Iron & Steel Co., Ltd., holds a large interest. In a similar manner the Bengal Iron Co., Ltd., is pursuing a progressive policy in regard to subsidiary industries in the vicinity of Kulti, and being a large shareholder in the Bengal Firebrick Syndicate is thereby certain of a regular supply of the numerous refractory materials required in its works, and at the same time assures the firebrick works of a steady market for a large proportion of its total out-turn.

(v) Castings. The Bengal Iron Co., Ltd., also owns one-half of the capital of the Eastern Light Casting Co., Ltd., which is erecting large foundries for the manufacture of light castings such as rain-water pipes, rice bowls, etc.

(vi) Miscellaneous. Other subsidiary industries, the establishment of which is being considered in various parts of India, include the manufacture of enamelled ware,

wheels and railway rolling stock, special steels, agricultural implements, ship and boiler plates, machinery for tea factories, jute and cotton mills, collieries, etc.

INDIAN IRON ORES.—The following data are taken from the annual and quinquennial reviews of mineral production in India, unless otherwise stated, and the interested reader is referred to them for fuller details. They form part of the Records of the Geological Survey of India.

Indian iron ores of economic importance may be classified as follows :

(1) Banded rocks composed of magnetite-hematite-quartz schists, associated with cherts, jaspers, and other rocks of Archæan age known as the Dharwars, which are now believed to be the oldest rocks wherever they occur in India. In these silica-iron ore rocks the latter constituent is occasionally concentrated into lenticular bodies of great size. These deposits are comparable with those of the Lake Superior region, Brazil, and other parts of the world, where similar geological conditions prevail.

(2) Bands and nodules of clay ironstone found in shales between the coal-bearing Barakar and Raniganj stages of the Gondwanas.

(3) Surface and sub-surface ores due to the segregation of iron oxide in the superficial deposits formed by rock weathering in tropical climates. These are generally found about the outcrops of the Dharwarian hematite schists, but they occur also in rocks of later geological periods.

The deposits of class (1) furnish the ores which are being smelted to-day, or which it is proposed to reduce in the near future. Those of class (2) supplied the ore in the early days of modern smelting in Bengal, but their use has been discontinued. The ores of class (3) were worked by the native smelters to some extent in the past, but they are only employed for special purposes on a small scale at present, for example by the Burma Corporation, Ltd., as a flux in lead-ore reduction, and there are no reliable estimates of their total extent.

The best known examples of class (1) are :

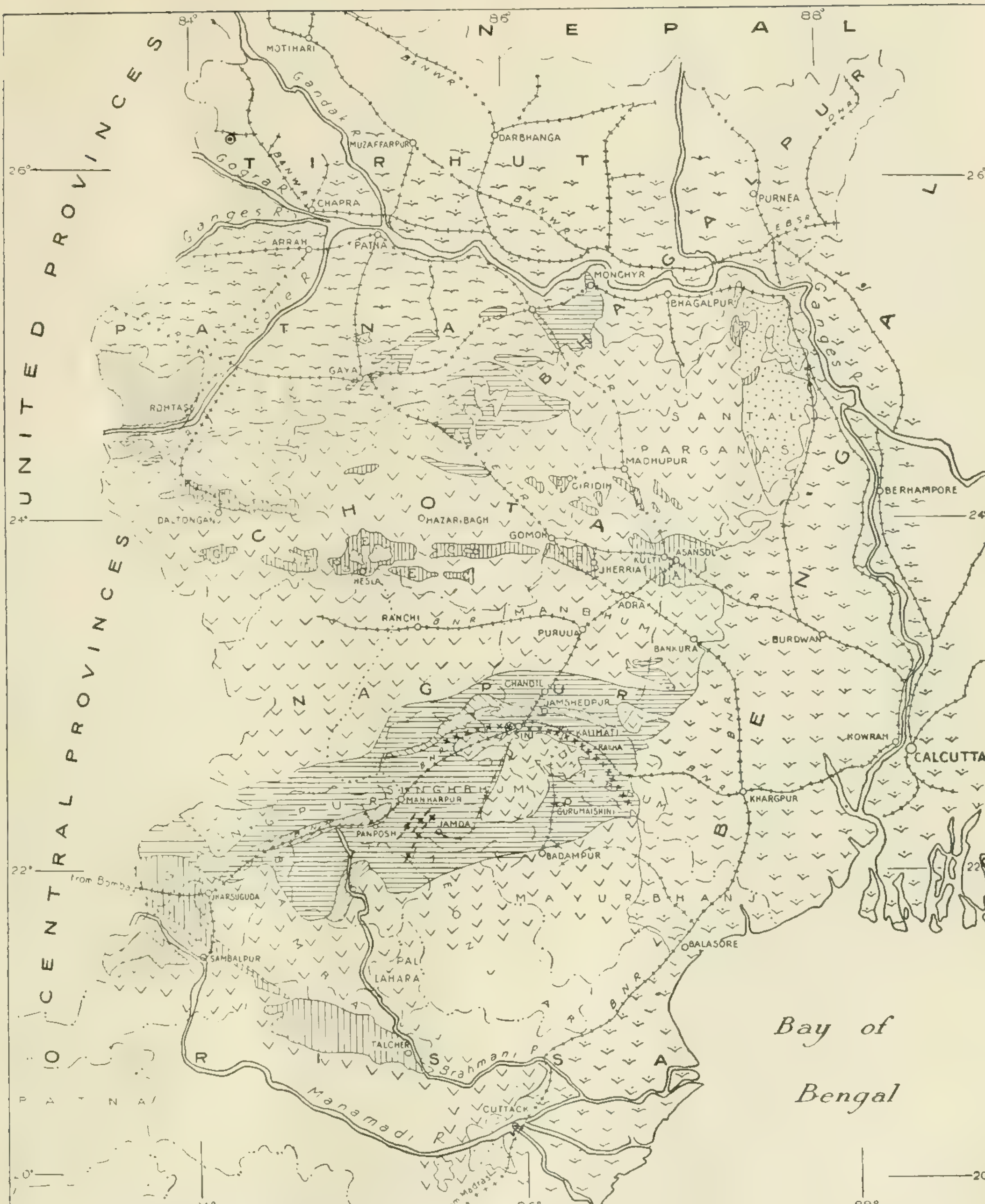
(*a*) The deposits of Singhbhum and the feudatory States of Orissa.

(*b*) The deposits of the Chanda, Drug, and other districts of the Central Provinces.

(*c*) The deposits of the Kadur district of Mysore.

(*d*) The deposits of Goa and Ratnagiri.

SINGHBHUM.—This is the name given to a district with an area of about 3,900 square miles which lies in the south-east of the Chota Nagpur division of the Province of Bihar and Orissa. It forms part of the southern fringe of the Chota Nagpur plateau. The eastern portions are comparatively open, but elsewhere it is very hilly. The ranges have a general maximum height of about 2,000 ft., which is exceeded by the isolated peaks. The Government estate of Kolhan, where very large deposits of iron ore occur, is in the south-west, while the estate of Dhalbhum lies to the east. Singhbhum is bounded on the west by the Gangpur State, which contains important manganese and limestone deposits, and on the south by the feudatory States of Orissa known as Mayurbhanj, Keonjhar, and Bonai. Geologically, its most interesting feature is a great batholith of granite which has lifted up the Dharwar phyllites and schists. (See map.) A portion of the southern lobe of the granite is included within the boundaries of Mayurbhanj. The chief iron-ore deposits of this State lie within the Dharwar rocks to the east of the batholith and between it and the main mass of the granite traversing the States to the south. The Singhbhum iron-ore deposits and the iron-ore ranges recently discovered in the Kolhan estate occupy roughly a similar position to the west of the batholith. Before describing the iron ores in greater detail it may be mentioned that Singhbhum is a highly mineralized region. Close to the northern margin of the batholith, and extending further to the south-east and west, is the well-known copper belt, a line of workings made by the ancients in their search for copper ores. The Rakha mines of the Cape Copper Co., Ltd., are close to the extreme north-eastern lobe of the batholith. Several miles to the north there is a large intrusion of dolerite now altered to epidiorite, known as the Dalma trap. At intervals along the copper belt there are small lenticular bodies of magnetite-apatite rock. At Kalimati, 5 miles north of the granite, wolfram occurs in quartz veins. Nearer the Dalma trap argentiferous galena has been found at Dhadka. In addition, various auriferous quartz lodes are known, while chromite is associated with peridotites to the south-west of Chaibasa. The geological structure and ore deposits of this interesting region have been described by V. Ball, J. Malcolm Maclaren, L. L. Fermor, C. M. Weld, and H. C. Jones, to all of whom the writer is indebted.



GEOLOGICAL MAP of BIHAR and ORISSA

after V. Ball, J M Maclaren, L L Fermor and others

Scale — 1 inch = 32 miles

- Recent & Sub Recent.
- Upper Gondwanas
- Gondwana Coalfields.
- Cuddapahs etc
- Dalma Trap
- Dharwars
- Granite Gneisses etc.
- Iron Ore Ranges
- x x x x x x x x x Copper Belt.

COALFIELDS

A	Raniganj.	E	Karanpura.
B	Jherria	F	Auranga.
C	Ramgarh-Bokaro	G	Hutar.
D	Giridih.	H	Daltonganj.

The main line of the Bengal-Nagpur railway from Calcutta to Bombay crosses Singhbhum from east to west. At Sini junction it is joined by a line running down from the Bengal coalfields. The new railways under construction to open up the iron ore deposits are indicated on the map.

The iron ore deposits that have been exploited for the longest time are those of Pansira and Buda Hills, leased by the Bengal Iron Co., Ltd. The mines are situated about 12 miles and 8 miles respectively south-east of Manharpur station on the Bengal-Nagpur railway, with which they are connected by a narrow-gauge line. The ore takes the form of veins and bodies of hematite in banded iron ore-silica rocks. Many millions of tons have been proved, and the following is a typical analysis: Fe = 64·00; Si = 2·10; Mn = 0·05; P = 0·05.

With these deposits as a starting-point, further prospecting has led to the discovery of iron ore ranges, which are believed to continue for forty miles in a south-south-westerly direction into the Keonjhar State, only a portion of which has been examined up to the present time. The most important range has been surveyed for about 10 miles. It rises some 1,500 ft. above the surrounding plain and its top is formed of good iron ore almost without a break. Another parallel line of hills has been traced for 7 miles, in which the iron ore occupies the same position. In the southern portion it is as good and continuous as in the adjoining range, but in the north replacement is less complete. In a third range the ore is confined to patches which are, however, of considerable importance. To the west of these ranges there are more irregular patches of ore occupying the tops of the hills. These hematites usually appear to average about 64% of iron, with phosphorus ranging between 0·03 and 0·08, or, in some cases, to as high as 0·15. The sulphur content is usually below 0·03. Titanium is also said to be found occasionally in the ore, usually either as a trace or in very small quantities. Samples from the better parts of the deposits contain as much as 68 or 69 % of iron. Although comparatively little work has been done hitherto by the concessionaries, enough is known, according to Sir Henry Hayden, to justify the belief that the quantities available will run into hundreds—possibly into thousands—of millions of tons. A branch of the Bengal-Nagpur Railway now under construction from Amda to Jamda will open up part of this region.

Mr. H. C. Jones, of the Geological Survey of India, who is now making a detailed investigation of these deposits, has shown that the rocks generally consist of shales or slates and phyllites, with beds of sandstone, quartzite, and hematite quartzites. The latter form the main part of the iron-bearing series. The ore-bodies are believed to have been derived from these rocks by local enrichment, largely by the leaching of silica and to a less extent by the introduction of iron oxide.

The iron ore deposits of Mayurbhanj, first noticed by the Indian geologist Bose, are great lenticular leads or bodies of hematite, with small quantities of magnetite associated with banded quartzites and quartz-iron ore rocks. They are intimately connected with granite on the one hand, and granulite rocks of the charnockite type on the other. About a dozen ore-bodies have been located in this State, which are now estimated to contain some 39,400,000 tons of non-titaniferous ores of 60 to 67% of metallic iron. (See C. P. Perin: "The Recent Development in the Iron and Steel Industry of India": American Iron and Steel Institute, October, 1920, p. 5.) The more important ones are the following:

(*a*) At Gurumaishini, this hill mass rises 3,000 ft. above sea-level. The ore deposits occur in three parallel and separate leads, measuring 7,000, 5,500, and 3,000 ft. respectively in length and varying from 300 to 700 ft. in breadth. The total area is estimated at 19 millions of square feet, and the total quantity of ore at many millions of tons. The average composition of the solid ore is Fe = 64·33; P = 0·075; S = 0·021; SiO_2 = 1·64. A great deal of "float" ore of somewhat lower grade (Fe = 61·5) exists. The iron ore mines from which the Tata Co. draws its present supplies are at Gurumaishini.

(*b*) At Okampad, a single great lens of iron ore, 12 miles to the south-south-west of Gurumaishini, covers an area of 300,000 sq. ft., and exhibits at one point a scarp 300 ft. high. There are also two smaller outliers and a large area of rich "float" ores. The average analysis of four samples gives the following results: Fe = 63·11; P = 0·029; S = *nil*.

(*c*) At Badampahar, 8½ miles to the south-west of Okampad, rises the peak of

Badampahar, elevation 2,706 ft. Here there is another single great ore-body, approximately 3,000 ft. long by 500 ft. in breadth, which with many smaller outliers occupies the crest of the hill. Outcrops of massive ore have been measured through a vertical distance of 600 ft. A broad-gauge extension of the Gurumaishini Railway is now under construction from Onlajori Station on the Tatanagar-Gurumaishini branch, to open up the Okampad and Badampahar deposits, and preliminary operations are in progress to develop the latter.

There are indications that similar geological conditions may exist in the Pal Lahara State of Orissa, which is separated from Mayurbhanj by the Keonjhar State.

Chanda District, Central Provinces.—The deposits form well-marked bands associated with the Dharwar rocks. The ore is usually a very high-grade hematite. At least ten separate deposits have been located, and some of them are of large size. The two best known are at Lohara, where the ore forms a hill nearly half a mile long, 200 yards wide, and 120 ft. high, and it has been traced for a further distance of 2½ miles; and Pipalgaon, where there is a very fine mass of red hematite. The Lohara deposit is leased to the Tata Iron & Steel Co., Ltd., by whom it is held in reserve, except when small quantities of this quality of ore are wanted for special purposes. The grade of the ore may be judged from the following analyses:—

Lohara: Fe = 69·21; S = 0·012; P = 0·005; SiO_2 = 0·82.

Pipalgaon: Fe = 71·05; S = trace; P = trace; SiO_2 = 4·5.

Drug District.—The iron ores form conspicuous hillocks rising above the level of the surrounding country. The most important of these is a ridge including the Dhalli and Rajhara Hills, which extends for 20 miles and attains heights of 400 ft. above the plain. The ores are associated with phyllites, and are often of a banded quartz-iron ore type, but in places thick lenticular masses of comparatively fine hematite occur. Mr. C. M. Weld proved 2½ million tons by diamond drilling in the Rajhara mass. An adjoining deposit is assumed to contain 7½ million tons, making a total of 10 million tons, carrying 67 to 68% of iron with 0·06 to 0·09% of phosphorus.

Similar iron ores are now known to have a very considerable extension into the Bastar State to the south, and they are said by Mr. C. P. Perin to carry a tonnage of from 20 to 30 times that now reasonably accurately known.

Mysore.—Smeeth and Iyengar give particulars of these deposits in *Mineral Resources of Mysore*, 1916, p. 65. Iron ores are widely distributed in Mysore, but are very variable in character, and in comparatively few places are abundant or pure enough for modern operations. The best known ores are those of the Bababudan hills in the Kadur district. The crest of this horseshoe-shaped chain of hills is formed nearly entirely of banded quartz-iron ores, largely hematite with some magnetite. The various ore fields are separated by intrusive diorites, often altered into ferruginous clays, or patches of soil and jungle, or quartzites, where the overlying series has been denuded away. A great many million tons of ore exist in this region, but in widely separated patches difficult of access. The following tentative data refer only to one small patch known as the Kemmangundi field, and are believed to be conservative. The area is about 50 acres and the surface conditions are expected to continue to 50 ft. or more in depth. Taking an average depth of only 25 ft., the total tonnage is estimated at 4,000,000 tons of an average composition of Fe = 57; SiO_2 = 2; S = 0·05; and P = 0·08. This and a smaller deposit in the vicinity are estimated to yield three-quarters of a million tons with Fe = 61 to 62, and P = 0·05, and two million tons with Fe = 56 to 57, and P = 0·09. These are only two deposits out of a large number at distances of from 1 to 10 miles from this point.

On an area of 9 or 10 square miles in the neighbourhood of Kalhattigiri, the ore exists practically at the surface, and Dr. Smeeth has concluded that 3 square miles are occupied by good ore. Assuming that the surface ore extends to at least 10 ft., the amount available is 83,000,000 tons. The outer crusts, say to 3 or 4 ft., would yield 25,000,000 tons, carrying 60 to 65% iron, and the remaining 6 or 7 ft. some 60,000,000 tons containing 55 to 58% iron with about 8% of combined water. The amount of phosphorus is somewhat high, varying from 0·044 to 0·105%.

Goa and Ratnagiri.—The iron ores of these regions are of Dharwarian age, and crop out in the midst of laterites. At the surface they are mixtures of limonite and hematite with minute crystals of magnetite. At Bicholim in Goa the main ore band has

been traced for 7 kilometres, and is said to vary from 30 to 100 metres in width. The hard ore is believed to be a surface hydrated form of a friable, schistose, micaceous hematite found unaltered at about 50 ft. below the surface. On account of the extent of the outcrops, however, the hard ore is probably available in large quantities. Analyses show that it is of high grade, very low in silica, and with a phosphorus content below the Bessemer limit. The Ratnagiri ores are of the same type.

OTHER ORE DEPOSITS.—Iron ores occur throughout peninsular India in association with the ancient crystalline rocks of which it is built up, but by far the majority of them are so intimately blended with quartz that only a very siliceous low-grade material can be obtained without concentration. These occurrences of quartz-iron ore schist are so common that newly recorded instances of them are generally passed over as matters of very little immediate economic interest. An attempt has been made in the preceding paragraphs to indicate how, during the past few years, more detailed survey work has brought to light distinct ore-bodies of great size and richness, especially in the Central Provinces and Singhbhum, Mayurbhanj, and Orissa. No useful purpose could be served by giving the very lengthy lists of all the iron ore occurrences which are known in practically every province. These have already been collected by T. H. D. La Touche in his annotated index of Indian Minerals of Economic Importance.

COAL SUPPLIES.—The question of the supplies of metallurgical coke which are likely to be required to meet the expansion of the Indian iron and steel industry is a most important one, and may now be considered briefly.

The output of coal in India is steadily increasing, having risen from about 5 million tons per annum twenty years ago to over 20 million tons to-day. The total production in 1919 amounted to 22,628,000 tons, without reckoning the amount taken by the miners for their own use. Of this total, the Jherria and Raniganj fields produced 53·68 and 30·12% respectively, and the smaller Gondwana coalfields of Bihar and Orissa a further 8·56%.

In 1918 the Government of India, in view of the large avoidable waste of coal known to occur on the Raniganj and Jherria fields, engaged Mr. Treharne Rees to visit them and advise on the best methods of securing greater economy in the production and consumption of coal. Mr. Rees' report was submitted in August, 1919, and his principal recommendations include more efficient methods of coal extraction, the more economic use of power and more general employment of electricity, the improvement of methods of coke-making, the introduction of coal mixing, the more extended employment of screening, the possibilities of briquette manufacture, etc.

In January, 1920, the Government of India appointed a committee to consider Mr. Rees' report. It included representatives of the royalty owners, mining associations, firms engaged in mining, the Director of the Geological Survey of India, the Chief Inspector of Mines, and the Mining Engineer to the Railway Board. This committee toured the coalfields, examined numerous witnesses, and published a lengthy report in June, 1920.

In dealing with the question of coke production the committee show that only very approximate figures are available of the higher grade of coking coal reserves. The Raniganj coalfield alone contains over twenty thousand million tons of coal of all kinds, but most of this is inferior and only 518 million tons of first-class coal are estimated to exist. The addition of the Jherria reserves of the best coal brings the total up to nearly a thousand million tons. To the west of Jherria the Bokaro field is said to contain over six hundred million tons of coking coal, and it is possible that further reserves will be found in the untouched Karanpura fields still further to the west. Apart from these the only other coking coal known to occur in any quantity in India is that of Assam, the high sulphur content of which, however, makes it unfit for metallurgical purposes. The committee concluded that as far as is known at present, India will be dependent for metallurgical coke on the fields of the Damuda valley, and that although the total amount of coal they contain is undoubtedly very large, the quantity available for coke manufacture is strictly limited. Unless the resources are conserved and the use of the coal of lower grade substituted, wherever possible, for that of the better coking qualities, India may be faced at no very distant date with the loss of her metallurgical industries for want of coke. If the present rate of increase is maintained and an opportunist policy persisted in, the known reserves of two thousand million tons of

high-grade coking coals would be extracted in forty years.

Having come to this conclusion the committee made a number of recommendations to the Government of India, which still has them under consideration. These included the formation of a new Government Department and a Board as controlling authorities with legal powers designed to ensure conservation and economic extraction of coal.

It is necessary to point out that the mining engineer of the Railway Board submitted a minority report in which he stated his own personal belief that in the recently proved portions of the Jherria and Raniganj fields and in the Bokaro and Karanpura fields there are at least 300 years supply of good quality coal available.

It will be seen that the authorities are well aware of the position, and in the writer's opinion there is no need to fear that the growth of the Indian iron and steel industry is likely to be checked by the lack of metallurgical coke. Apart from the question of conservation, there are possibilities of extensions to known reserves of high-class coal in the undeveloped fields and to the results of research in the mixing, washing, and flotation of the poorer qualities.

The results of recent investigations in the United Kingdom on froth flotation as applied to the washing of industrial coal are of peculiar interest to India, as they have demonstrated that metallurgical fuels of a high degree of purity can be made from coals possessing a high ash content.

Conclusions.—According to Mr. C. P. Perin : " Since the beginning of the war prospecting parties have been continuously in the field working in a quadrangle 400 miles east and west by 200 miles north and south, beginning at Calcutta as the north-east corner. After investigations by some twenty prospectors, engineers of experience, and geologists connected with the different companies, there is now estimated to be about 20,000 million tons of high-grade iron ore within a maximum distance of the fuel of 500 miles and an average distance of 120 to 130 miles."

It will thus be seen that India possesses sufficient high-grade iron ores to supply an iron and steel industry of the first magnitude, and the rapid developments which are taking place show that this fact is fully appreciated by capitalists. The day would not seem to be far distant when India will be self-supporting as regards iron and steel and probably exporting pig iron to outside markets, for in the opinion of those best able to judge it can be produced comparatively cheaply, owing to the low assembly costs consequent on the close proximity of raw materials and the cheap rates of freight.

THE DIP COMPASS

By HENRY LOUIS, M.A., D.Sc., A.R.S.M., M.Inst.C.E., etc.,
Professor of Mining, Armstrong College, Newcastle-on-Tyne.

Methods of magnetic surveying are employed for locating such ore deposits as distinctly affect an ordinary magnetic needle ; such are mineral deposits that consist, or, at any rate, contain a large proportion, of either magnetite or pyrrhotite ; the former occur extensively in Scandinavia, Canada, and the Northern United States, as well as less abundantly in other places, while the best-known example of the latter is to be found in the important copper-nickel deposits of Sudbury, where these magnetic methods have, in fact, rendered excellent service. Comparatively recently attempts have been made to extend the principles involved to the location of ore-bodies of relatively low magnetic permeability, such as beds of ordinary ironstone. The method was elaborated by Mr. G. W. Walker under the auspices of the Iron Ore Committee of the Conjoint Board of Scientific Societies, of which I was Chairman, and a full report will be found in the *Philosophical Transactions of the Royal Society*, series A, vol. ccxix (1919), page 73. This method, however, requires elaborate and delicate instruments, and its consideration is beyond the scope of the present article, which refers exclusively to the methods as above defined. Owing to the fact that so many of the Swedish ore deposits carry large proportions of magnetite, these methods have originated and have been mainly worked out in Sweden. The earliest form of instrument appears to have been the Swedish so-called miner's compass, the invention of which is ascribed to Daniel Tilas, who died in 1672. As will be seen from Fig. 1, it consists of a cylindrical brass box, usually $1\frac{1}{2}$ to 2 in. in diameter, and of about the same depth, with a domed

glass cover. In the centre of the box there is a long steel pointed pin, on which revolves a cap, to which a magnetic needle is pivoted, so that this needle is free to move in both a horizontal and a vertical plane. There are no graduations, but a line is drawn round the inside of the box, which indicates the normal level of the north-seeking end of the needle when subject only to the magnetic influence of the earth. If this instrument is taken to any place where there is any magnetic influence other than that normally due to the earth, the north end of the needle will come to rest either above or below the marked line, and from its position an experienced man can tell whether magnetic deposits of any importance are likely to exist or not below the spot that is thus tested. It will be noted that the appliance is a crude one, but its indications are quite useful to a skilled observer.

Another form was introduced into the United States about 1866, which is generally spoken of as the American dip compass (see Fig. 2). It consists of a shallow brass box, 3 to 4½ in. in diameter, and ½ to ¾ in. deep, in which a magnetic needle is suspended on a horizontal axis so as to be capable of moving in a vertical plane only. The flat sides of the box are made of glass, and it contains a graduated arc so that the amount of dip can be read off. It is made by Messrs. W. & L. E. Gurley, of Troy, New York, and other American makers, and has also been copied by instrument makers in this country. In use it is placed horizontally and turned until the needle points to the zero of the graduation, and is then turned up into a vertical position so that the needle swings in the plane of the local magnetic meridian, when the amount of dip can be read off from the graduations. About 1898 I introduced an improved form in which I attempted to combine the advantages of the American and Swedish instruments; this I described fully in 1899 (see *Journal of the Iron and Steel Institute*, 1899, i, p. 80). It consists of a box like the American compass, only deeper, being 3 in. in diameter and 1½ in. deep, with glass sides. The needle is suspended as in the Swedish instrument, and behind it a semicircular arc is pivoted concentrically with the horizontal axis of the needle, so that the arc always hangs with its zero line horizontal. By turning the box until the needle swings freely about the vertical suspension it sets itself in the local magnetic meridian, and the amount of dip can be read off with considerable accuracy. The instrument is made by Mr. F. Robson, of Newcastle-on-Tyne, and I was able to do some good work with it. I have, however, abandoned it entirely for the form which I propose to describe presently. It had two drawbacks: the delicate suspensions were too apt to become deranged with work in the field, but above all it shared with all the instruments above described the serious drawback that it indicated dips in the plane of the local magnetic meridian, the objections to which method will be pointed out in the sequel.

Meanwhile, between 1870 and about 1880, two Swedish instruments, the Thalen magnetometer and the Tiberg inclinator, had been devised; they were subsequently combined in one instrument, which is practically the only instrument used at all extensively in Sweden to-day, and which is known as the Thalen-Tiberg magnetometer. This is used for making complete magnetic surveys of the area in which there are reasons for supposing that magnetic minerals occur; by this means curves of horizontal and vertical intensity can be plotted, from which the position of the ore deposit can be deduced. For a full description of these methods, the reader may be referred to a small work on the subject by Eugene Haanel, "On the Location and Examination of Magnetic Ore Deposits by Magneto-metric Measurements," published by the Canadian Department of Mines in 1904, which is entirely based upon the well-known work of Th. Dahlblom published at Falun in 1898. Without denying that this method may at times give information of the highest importance, my own experience has been that the results from an economic standpoint are not always reliable. Moreover, it is a somewhat slow and laborious method, and I have for some time past come to the definite conclusion that the results obtainable by it are not commensurate with the cost and labour involved in obtaining them. I have, therefore, reverted to the simple reading of dip angles as in the American dip compass, but have adopted the form of needle used in the Swedish magnetometer, which is intended to be read in a plane at right angles to the magnetic meridian. The dip compass thus designed, which I have used very successfully for a good many years, is now being put on the market by Messrs. T. Cooke & Sons, Ltd., York.

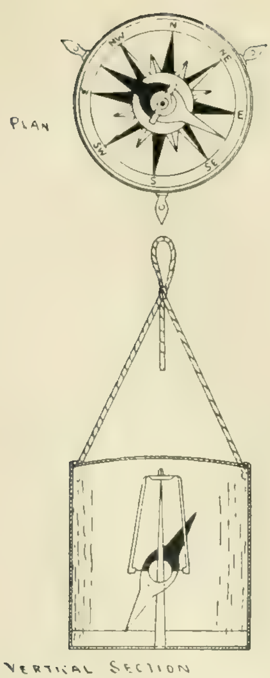


FIG. 1.

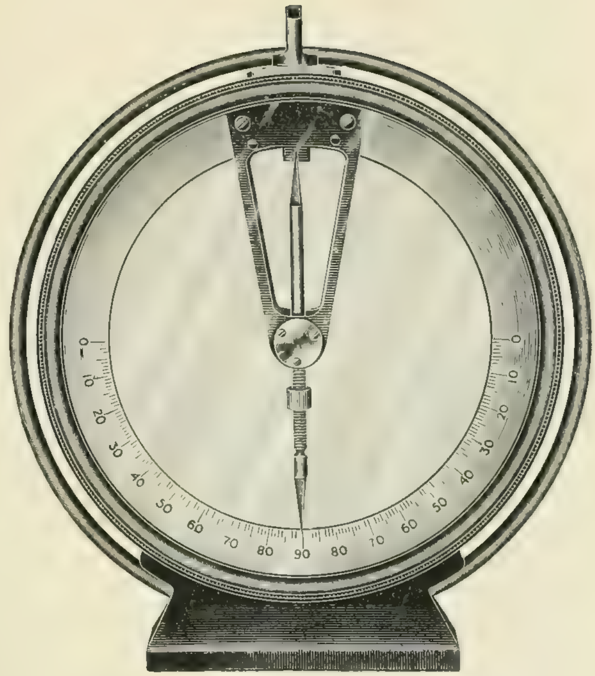


FIG. 3.

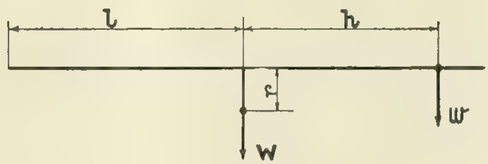


FIG. 4.

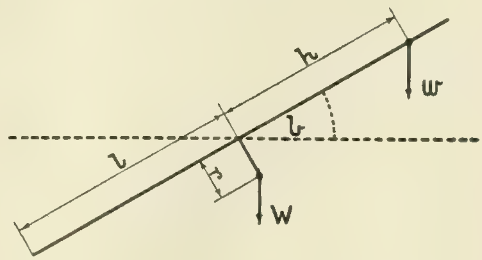


FIG. 5.

FIG. 2.

As shown in Fig. 3, it consists of a brass box, some 4 in. in diameter by about $\frac{3}{4}$ in. deep, the sides being made of glass, or better still, of transparent celluloid. It is suspended by a gimbal attachment, so that when held freely it hangs so that the line adjoining the zeros of graduation is truly horizontal; the base also allows it to be set on any level surface when more accurate observations

are desired. In the field I often use a light hand camera tripod for this purpose. The needle is suspended in carefully centred jewels, and it is necessary that much care and close attention should be bestowed upon the horizontal axis, so that the suspension may be highly accurate and work with the minimum of friction. The needle has a screw thread cut on one end (usually the south-seeking end), and on this a counterpoise, in the form of a small nut, moves smoothly but stiffly, so that the needle may be accurately adjusted in a truly horizontal position. Below the centre of the needle is a short pin of hard brass, also with a fine screw thread cut on it, and a little milled nut travels on this, so that the centre of gravity of the system can be brought to any desired point below the centre of suspension. By placing it flat and turning the box the needle can be brought into coincidence with the 90° mark of the graduation ; on now turning the instrument into a vertical position, the needle will be constrained to move in a vertical plane at right angles to the local magnetic meridian.

In order to understand the principles involved, it is necessary to recall briefly some of the elementary facts concerning the magnetism of the earth. If a magnetized steel needle be suspended quite freely from its centre of gravity, it will set tangentially to the lines of force in the magnetic field of the earth at that point, or, in other words, the magnetic force of the earth will be acting along the axis of the needle. It is convenient to resolve this force into its horizontal and vertical components ; in order to give some idea of the forces involved it may be mentioned that in this country the horizontal intensity (H) is about 0·185 C.G.S. units, and the vertical intensity (V) about 0·435 C.G.S. units. It need hardly be said that these values are continually changing, though the change is a relatively slow one.

Assuming that a magnetic needle be suspended from its centre of gravity in the plane of the magnetic meridian at a spot where it is subject only to the magnetic influence of the earth, it will then have a definite dip or inclination ; let the angle of inclination measured from the horizontal be I ; now let the needle be placed in another plane making an angle a with the plane of the magnetic meridian, and let its dip be i. Then $\tan I = \frac{V}{H}$; in the second position the horizontal intensity becomes $H \cos a$, hence $\tan i = \frac{V}{H \cos a} = \frac{\tan I}{\cos a}$. Accordingly, when a is 90°, or the needle is in a plane at right-angles to the magnetic meridian, i becomes 90°, and is then a maximum. Furthermore, it is evident that in this position H has no effect upon the inclination of the needle, and its action is therefore eliminated. If a needle be brought to a spot where it is subject to a magnetic influence other than that of the earth, as, for instance, if it is brought near a mass of magnetite, if the needle is in the plane of the local magnetic meridian, both the horizontal and vertical components of the field due to the mass of magnetite as well as those due to the field of the earth will affect the needle. Conceivably the components of the former might be in the same ratio as those of the latter, and in this case the dip of the needle would not be altered, and the presence of the deposit would not be detected ; even if this were to occur, it would only be in one position, and the presence of the deposit would be detected by an alteration in the dip of the needle as soon as a second observation was made. Moreover, in the vast majority of cases the vertical component due to a mineral deposit below the surface of the earth is much greater than the horizontal component, and therefore the dip of the needle is in most cases affected. It is, however, obvious that since the dip depends upon a number of variable conditions, the relation between the angle of dip and the magnitude of the magnetic forces involved cannot be stated in general terms, but must be determined independently for each set of conditions ; it can only be said quite generally that the extent to which the dip is affected will as a rule be greater, the greater the magnetic forces involved. In other words, observations with the magnetic needle in the magnetic meridian have a qualitative but not a quantitative value. It is on this account that I now always work with the magnetic needle at right angles to the plane of the meridian when quantitative measurements can be obtained, as will appear from the following considerations.

In Fig. 4 w is a counterpoise sliding along the needle to counterbalance the vertical component of the earth's magnetic force when the needle is in a plane at right angles to the magnetic meridian ; it is set at a distance h from the centre of the needle, and W is a small weight placed at a distance r

from the centre of suspension of the needle. Let the distance between the poles of the magnetic needle be $2l$ and let m be the magnet pole strength. Then $wh = mV2l$.

Now let the needle be brought into a field whose strength vertically is $V + dV$, where dV represents the change in the vertical component of the field, and let the needle now come to rest in an inclined position making an angle of inclination b to the horizontal (Fig. 5). The equation of moments is now $w\ h \cos b + W\ r \sin b = m\ V2l \cos b + m\ (dV)\ 2l \cos b$, whence $\tan b = \frac{m\ (dV)\ 2l}{Wr}$ and $dV = \frac{Wr \tan b}{m\ 2l}$.

Thus the change in the field is proportionate to the tangent of the angle of inclination; for small angles no serious error will be committed if the change in the field is taken as proportional to the angle itself. Furthermore, it will be seen that the angle becomes greater as r is diminished, so that the needle can be made very sensitive, and will indicate bigger angles of inclination for the same change in the magnetic field if the small weight W is brought closer to the point of suspension of the needle. By the construction of the instrument m, l, and W are constant.

In order to make a series of observations, the needle must first of all be adjusted at a place near the field to be investigated, where there is no magnetic attraction other than that of the earth itself. The compass is now placed flat and turned until the south end of the needle coincides with the 90° graduation; it should be gently tapped to make sure that it is in the magnetic meridian. The compass box must now be turned into a vertical position when it will be in a plane at right angles to the magnetic meridian; one of the side cover glasses is now removed, and the counterpoise w is screwed to and fro until the needle is exactly horizontal. The cover glass is replaced, and the instrument is taken to the field to be examined. The same procedure is repeated; the instrument is held horizontally until the south end of the needle, moving freely, coincides with the 90° graduation mark. It is then turned into a vertical position and the inclination of the needle is noted; inclinations of the north end are usually given a + sign, and those of the south end a — sign. If the readings are too small or too large for convenience, these can be altered by moving the small weight W towards or from the point of support, but its position must not be again altered while a set of readings are being taken in a given field.

It will be noted from the above investigation that if the plane of the needle does not coincide exactly with the plane perpendicular to the magnetic meridian, a small deviation will produce no serious error. Seeing that $\cos 8° = 0{\cdot}99$, even if the plane of the needle is 8° out of the plane perpendicular to the meridian, the error in the tangent of the angle of inclination would only amount to 1%.

If desired, this dip compass can be used for setting out curves of equal vertical intensity, exactly as is done with the elaborate and expensive Swedish instrument, the method here recommended being at least as accurate and much more rapid, although it requires two observers. Instead of setting out a network of squares over the ground as is done in the Swedish method, I recommend that one observer use the dip compass, in conjunction with another who will plot the position of the first observer by surveying, preferably using a plane table. For this purpose I strongly recommend the use of the tacheometric plane table (see my paper on this subject in the *Transactions of the Institution of Civil Engineers*, vol. cciii, 1917, page 359). This method will be found satisfactory and expeditious, and can, of course, be combined with the survey of the area under examination.

This form of dip compass also renders important services underground when working deposits of magnetite or pyrrhotite. Assume that an approximately vertical lenticular mass of such ore has been opened up by means of an adit which has penetrated into the ore-body; obviously if a dip compass be taken into the adit it will be affected by the ore both above and below the adit; at the surface above the deposit the needle will probably show a well-marked dip; the dip will be less in the adit because the portion of the deposit above the adit will be drawing the needle upwards while the portion below the adit draws it downwards, and it is thus easy to determine whether the adit has cut the deposit above or below its centre, and even to form some idea of the depth to which the deposit is likely to extend. If the deposit is opened up at several different levels and such observations are made at each level, quite reliable conclusions as to the permanence in depth of the deposit can be drawn.

BOOK REVIEWS

A Geological Map of the World. By HENRY B. MILNER, M.A., F.G.S. On Mercator's Projection, one sheet 45 in. by 28 in. Price 25s. net. London: Edward Stanford, Ltd.

The primary object of this publication is the presentation in an easily accessible form of an accurate geological map of the world, compiled from the most recent and authentic stratigraphical criteria available. For a long time the need has been felt for a general "index" map of this nature, which, while omitting detailed definition such as must necessarily be obtained from a study of original large scale maps of a particular region, depicts the broader outlines of the geology of the country whereof that region forms a part. Moreover, the co-ordination and correlation of the results of stratigraphical work by different geologists in contiguous countries is desirable in order that our geological knowledge of the continents of the world could be summarized as far as present data permitted. A comparison of this map with Marcou's well-known work published some fifty years ago shows at a glance the enormous amount of pioneer field-work carried out since that time, and if only as a tribute to the ability and perseverance of those engaged in this research, the map was most certainly justified.

Geological investigation, whether carried out by national survey or by private individuals, must of necessity be limited in scope; its very nature demands the careful observation of comparatively small areas in great detail if it is to be of ultimate scientific or economic value; hence there is bound to be a natural tendency towards the accumulation of a vast amount of local geological data, which, by reason of its magnitude, may and often does unconsciously mask the larger and fundamentally more important geological issues. This wider view of the potentiality of such work can only be appreciated by the co-ordination of the more far-reaching elements of knowledge locally amassed, and a geological map of the world would seem to be the best medium for utilizing such knowledge to the fullest extent in illustrating the fundamental geology and tectonics of the earth's crust. Particularly in the study of such authors as Suess or de Lapparent is a map of this description desirable for constant reference, to promote cohesion of thought and to facilitate the grasp of doctrines which they seek to establish.

The map is drawn on Mercator's projection, and its size is approximately 45 in. by 28 in.; latitude and longitude are clearly defined to enable precise localities to be fixed, but no place-names whatever are printed on the map. Inclusion of such names would have undoubtedly complicated the intricate geological detail shown in many cases, and would have made the defining lines between different geological systems difficult to follow, especially in such countries as Europe and North America; actually this omission of place-names is of little consequence to those to whom the map will make its greatest appeal, since it may be safely presumed that their geographical knowledge is comprehensive enough to embrace such names as might possibly have been incorporated in a map of this size. In any case its study in conjunction with topographical maps of the countries represented is advocated by the author. The colours used are as far as possible uniform with the standard international colour-scheme adopted in publications of this nature, though certain additional conventions have been introduced to depict undifferentiated geological systems such as the Trias-Jurassic, as in Australia, New Zealand, South Africa, etc. In the pamphlet issued with the map, the author explains the reasons for the blank spaces occurring, and for the omission of certain geological data resulting from the survey of some of the better known inland watercourses of Central South America, Central Africa, and Siberia; in the former case either no authentic stratigraphical records exist, or if they do, their comparatively sketchy character inhibits their inclusion; in the latter instance the reduction to the varying scale necessitated by the size and projection of the map of such results as are published is thereby rendered impracticable, and no possible scientific value would accrue to the mere insertion of a few short sinuous lines bordered by hazy, narrow bands of colour, representing the geology of one or two little known rivers. The author's contention that such blank spaces are better left until more areal work is carried out in those countries (when published results can easily be added by the intelligent reader) is certainly sound, and more in keeping with the character and purpose of this publication as a whole.

The specific utility of a map of this description is twofold: scientific and economic. Scientifically its uses are obvious in all branches of academic instruction; for the student it forms a basis for a broad and intensive study of the geology of the world; for the professional geologist it constitutes a ready means of reference to regional geology otherwise only accessible at a great deal of trouble and bibliographical research. Economically it portrays to the capable observer those essential geological factors cognate to any enterprise for the development of the natural mineral wealth of the world, since the dominant igneous or sedimentary nature of a particular region can be at once ascertained, the more important coalfields located, and the probable petroliferous regions suggested from a close study of structure and disposition of likely formations such as those of Tertiary age.

Copper Refining. By LAWRENCE ADDICKS. Cloth, octavo, 206 pages, illustrated. Price 17s. net. New York and London: The McGraw-Hill Book Co.

The book, to a large extent, contains the results of Mr. Addicks' personal experience in this branch of metallurgy, and comprises a series of articles each dealing with one of the problems of copper refining. These articles appeared originally in *Chemical and Metallurgical Engineering*, and have now been embodied in a volume, seeing that the literature dealing with the principles of operation of electrolytic copper refining is limited. The work is in a way unique, inasmuch as it deals largely with possible losses and errors in the various stages of copper refining, while the economic side of the subject is carefully considered throughout.

It contains 13 chapters under the following headings: I, Metal Losses; II, Metals in Process; III, Tank Resistance; IV, Current Density; V, Current Efficiency; VI, Impurities; VII, By-products; VIII, Furnace Refining; IX, The Requirements of Refined Copper; X, Copper from Secondary Material; XI, The Power Problem; XII, Elements of Design; XIII, Application to Other Fields.

The salient points in connexion with the sampling of the various refinery materials are clearly indicated. This is of the first importance in any investigation of metal loss, as the values shown by the sample have to be paid for whether they exist or not. Some assaying precautions are given, especially in connexion with bullion, and the author wisely points out that "mismanagement in the laboratory may easily affect the apparent or financial metal losses". Metal losses, such as those in slags, stacks, and processes, are dealt with; in the last-mentioned there are included such losses as: (1) silver and gold in outgoing copper, (2) silver in outgoing gold, (3) gold in outgoing silver, and (4) values such as selenium, platinum, etc., lost in by-products.

A careful survey is taken of the metals undergoing electrolytic treatment, and the means are indicated of checking the position at each stage of the process. Since this class of refining takes considerably longer than fire processes (which are as a rule not so satisfactory technically), there are large amounts of valuable metals locked up and these impose heavy interest charges. It is shown that an increase of current density is closely related to plant investment and the quantities of metals continually under treatment, while the power required increases nearly as the square of the current density. A detailed study is made of the possibilities of improving tank resistance, since, in practice, a number of resistances and counter electromotive forces have to be overcome. It is also shown that the current density is the factor of an electrolytic process which is more important than all others in the design and operation of a plant, as so many items depend upon it in order to obtain the best return for the capital invested.

The question of current efficiency is discussed, and the author shows that, although nine sources of loss are always present, yet they can all be kept low. In a badly running plant the current efficiency may be as low as 60%; he regards 85% as poor; good balanced operations will give 92%; while with efficiency regardless of expense 99% may be obtained.

About 20 pages are devoted to impurities, which are placed under six main headings: (1) Sources; (2) Exits; (3) Distribution; (4) Chemical requirements of refined copper; (5) Recovery of soluble impurities from the electrolyte; and (6) Recovery of insoluble impurities from anode slimes. Very useful information is given in connexion with the purification of the electrolyte, while the various elements, usually associated with copper, are discussed. The means by which the anode slimes are worked up into marketable materials are given, and the by-products

are divided into three main classes: (1) Those which are readily marketable in any quantity (gold, silver, platinum, palladium, lead, nickel, and antimony); (2) Those which have a limited and therefore a widely fluctuating market (bismuth, arsenic, cobalt, selenium); and (3) Materials which have no market at the present time (tellurium).

The requirements for a slime process are stated, and it is pointed out that, as the material usually runs 35 or 40% silver and ½% of gold, every by-product must be re-treated for values contained. As the slime is a valuable material, it is essential that the bulk of the gold and silver should be recovered as rapidly as possible. This involves three main steps: (1) The production of a nearly copper-free slime; (2) Smelting the slime from No. 1 to doré bullion; and (3) Parting the metal obtained. A considerable amount of attention is given to these stages, and the author shows, by means of flow-sheets, the advance which has been made in the treatment of copper-anode slimes during the past 20 years. This difficult branch of the metallurgy of a copper refinery is treated in a very lucid manner.

About 18 pages are devoted to Furnace Refining, and the various stages of the process are described: Charging, melting, flapping, skimming, coking, poling, and pouring. The section on pouring is of special interest, as development is traced from the Welsh practice of using a ladle holding some 15 or 20 lb. of copper to the special twin ladle with which casting can be conducted at the rate of over 100,000 lb. an hour. Some attention is given to the preparation of moulds, the formation and retreatment of slags, and the thermal efficiency of the refining furnace. As regards future developments, it is pointed out that, during 20 years, the furnaces have changed from 20 to 250 tons per 24 hours capacity, and larger furnaces could easily be built were there any justification for it. The hearth is now constructed of magnesite brick for corrosive charges, while the walls, verb, and sometimes the entire roof are now built of chrome or magnesite brick.

Although the bulk of the world's copper is refined electrolytically, yet two reverberatory treatments are retained: the anode and the refining furnaces. The first operation is satisfactory, but the latter, instead of being a simple melting, really becomes a complete refining; the author mentions the possibilities of the electric furnace and of continuous melting, but he considers the latter more attractive.

The requirements of refined copper are considered under the headings of conductivity, pitch, ductility, castings, and dimensions, over about 17 pages. Much useful information is given which is illustrated by means of graphs and references to original papers in the Transactions of the American Institute of Mining Engineers. The production of copper and incidental metals from secondary materials is often a paying proposition, and this book contains considerable guidance respecting the treatment of this class of material, which may consist of junk, mill products, metallurgical products, and refinery by-products.

The power problem of an electrolytic copper refinery is considered merely from the general requirements and limitations of the problem as a whole. There is, of course, available heat from the reverberatories for the generation of steam, and, if the running is sufficiently uniform, it may not be necessary to use power generated in other ways, such as by a hydro-electric or gas plant. The author places the current density at 18 amperes per sq. ft. in average practice and the temperature of the electrolyte at 130° F.; under these circumstances the power consumption will approximate 350 kilowatt-hours per ton of copper deposited. With a refinery having a capacity of 100,000 tons a year, a power capacity of 4,000 kw. should be available.

Under the heading "Elements of Design" some space is given to the location of plants. The author states that the nations of Europe, since the war, have developed a desire to control key industries complete within their borders, and this may bring about the building of new refineries. Important points in connexion with the design of the power-house, tank-house, and the furnaces are reviewed, while a certain amount of attention is given to silver-refining and to purification. Two main principles should be kept in mind in operating the plant: (1) All the impurities should be removed as far as possible at the anode furnace; (2) Operating conditions should be brought to the highest limits of uniformity.

The book is concluded with a chapter on the application of electrolytic refining to other fields, and the cases of the precious metals, zinc, and lead are specially considered. The electrolytic process for lead is particularly interesting, as it has to com-

pete with the efficient Parkes process, and apparently the only economic advantage it possesses is that the bismuth present can be saved.

Dr. Percy stated that metallurgy is the art of extracting metals from their ores and adapting them to various purposes of manufacture *with profit*. It has evidently been the object of the author to indicate those points, often small ones, where savings and improvements can be effected, so that the refinery may be worked under the best conditions for economical efficiency and a suitable return obtained for the capital expended.

The work contains a number of flow-sheets, diagrams of processes, and other useful data ; there are many suggestions for future developments and consequently much food for reflection. We strongly recommend this volume to all who are interested in the metallurgy of copper.

W. H. MERRETT.

A Text Book of Assaying. By C. and J. J. BERINGER. Fifteenth edition, revised by H. R. BERINGER. Cloth, octavo, 480 pages. Price 12s. 6d. net. London : Charles Griffin & Co., Ltd.

Those whose business it is to watch the development and progress of assaying in its various branches cannot have failed to notice the comparative scarcity of good books on the subject by English authors. America, with its huge mineral resources and constantly varying metallurgical problems, affords ample scope for new methods and modifications of existing methods to meet local conditions. Consequently it is not surprising to find that the majority of present-day books on assaying or metallurgical analysis are American in their origin or inspiration. It is all the more a matter for congratulation, therefore, that the work under consideration, well-known to mining men the world over, should reach a fifteenth edition.

The edition under review preserves the familiar form and arrangement of previous editions, and contains new matter relative to the assays of tin, tungsten, copper, arsenic, zinc, and manganese. The section on tin contains the assay method associated with the name of the late J. J. Beringer, and, with the account of Hutchin's lime method and of the Pearce-Low assay, constitutes an excellent survey of the present position of tin assaying. A valuable addition to this section is an appendix, containing the assay methods of the Eastern Smelting Company, Penang. The section on tungsten includes the latest work of Hutchin on the use of cinchonine. Other additional features are the well-known aluminium and hypo separations for copper, the Volhard assay for manganese, and Low's method for zinc.

It would perhaps be idle to criticize a book which has so firmly established itself as a standard book of reference. We confess to some surprise, however, that no reference is made either to any bismuthate method for manganese, or to the glyoxime method for nickel. It may be put forward that the cost of these reagents (a first cost only in the case of glyoxime, since it is readily recoverable) is a bar to their use on mines or works in remote districts. Nevertheless, in a book used so largely by students, we think they deserve at least a brief mention. It is presumably chiefly as an exercise for students that the dry assay of nickel and cobalt is given prominence.

Under the heading of chromium a gravimetric method is described for the determination of this element in steel. Standing alone as this method does, it is apt to create the impression that no other method exists for this purpose, whereas there are obviously several good and much used volumetric methods.

Some of these matters are inconsistencies rather than defects, and, containing as it does few methods that are not chemically sound, the book should continue to hold its own as a reference book for those connected with mines and for technical chemists in general.

B. DRINKWATER.

Compressed Air Plant. By ROBERT PEELE. Fourth edition, cloth, octavo, 506 pages, illustrated. Price 25s. net. New York : John Wiley & Sons ; London : Chapman & Hall.

The extension of the use of compressed air during the last decade or two and the certainty of a still greater recognition of its advantages in the near future make the subject one of considerable importance to engineers, whether civil, mechanical, or mining. How wide the field of application of this medium of power transmission has become may be judged by an enumeration of some of its employments : elevating, transferring, and stirring liquids in chemical works, atomizing liquids, spraying paint

and cement, blast-furnaces, glass-blowing, caisson and other subaqueous work, railway switching and signalling, air brakes, riveting and other pneumatic tools, sand-blast, refrigerating, haulage locomotives, hoists, flotation machines, coal-cutters, and rock-drills. In view of the difficulty of dealing with the subject in all its ramifications within a reasonable compass, the author, who is the professor of mining in the School of Mines of Columbia University, and the editor of the well-known and valuable *Mining Engineers' Handbook*, decided to confine himself mainly to the consideration of the production, transmission, and use of compressed air in mining.

The scope of the work is well indicated by the titles of the twenty-seven chapters into which it is divided: Introduction, structure and operation of compressors, the compression of air, wet compressors, dry compressors, compound or stage compressors, air-inlet valves, discharge or delivery valves, mechanically controlled valves and valve motions, performance of air compressors, air receivers, speed and pressure regulators, air compression at altitudes above sea-level, explosions in compressors and receivers, air compression by direct action of falling water, conveyance of compressed air in pipes, compressed-air engines, freezing of moisture deposited from compressed air, re-heating compressed air, compressed-air rock-drills, hammer drills, coal-cutting machinery, channelling machines, operation of mine pumps by compressed air, pumping by the direct action of compressed air, compressed-air haulage, measurement of air consumption.

The space allotted to the turbo-compressor will be considered by some hardly commensurate with the increasing attention which is being devoted to its development. It is true that below a capacity of 5,000 cu. ft. of free air compressed per minute, it is not the most economical type, but above that level of output it successfully challenges the highest grade reciprocating compressors. Entire absence of valves and reciprocating parts, compactness, freedom from vibration, suitability for direct high-speed electric or turbine drive, ower initial and maintenance cost, high capacity in proportion to weight and floor space occupied, and elimination of danger of explosions in air receivers and pipe lines due to the comparative absence of oil, make it an ideal machine where a large output is required. Turbo-compressors are now made in standard sizes with a capacity of from 5,000 to 50,000 cu. ft. of free air per minute to a pressure of 130 lb. or more per sq. in. The number of impellers in series may be as many as 30, the speed 3,000 to 5,000 revs. per min., and the horse-power as much as 13,000. The increment of the pressure per impeller varies from 2 to 8 lb. per sq. in., 4 or 5 lb. being common practice. About 20 impellers in series are required to produce a final pressure of 100 lb. per sq. in. at 4,000 revs. per min.

An interesting description is given of some installations of the hydraulic system of air compression developed by C. H. Taylor. Air is introduced into a column of water, and is compressed as it and the water fall together to the bottom of a shaft, where the air is separated and collected. The first cost is not disproportionately heavy for large outputs, while the efficiency is good, and maintenance and running costs very low. A peculiar feature attending this method of compression is the lowering of the percentage volume of oxygen in the air from 21% to 18%, with a corresponding increase in the nitrogen content. In some mines this has prevented the use of candles for lighting.

Much useful information is given concerning the air-lift. Since 1888, when Dr. Julius Pohlé drew attention to the possibilities of this device, its progress has been steady, if slow. It is specially applicable to the drainage of shallow mines and as an aid in unwatering old and flooded mines. It possesses the great advantage that, once installed, it can be operated entirely from the surface; no pumpmen are needed in the mine, and if the power fails and the water rises no pumps are lost. The efficiency is from 20 to 40%. Until recently it was thought that a submergence of 50% was necessary to obtain reasonable results, but an installation in a Mexican mine has shown that an efficiency of 30% is obtainable with a lift of over 1,000 ft. and a submergence of only 20%. The principles of the air-lift are as yet imperfectly understood, and its design is consequently faulty; but even in its present immature stage the work it is doing holds out considerable promise of its becoming a valuable auxiliary in mine drainage.

It is to the chapters on rock-drills that the mining engineer, remembering young and strenuous days with them in the mine and maturer days in the office wondering which sort to buy, will instinctively turn. J. J. Couch in 1849 began, and Sommeiller in 1861, Burleigh in 1866, Simon Ingersoll

in 1871, and J. George Leyner in 1897, continued the rock-drill's slow, irresistible development. The old, two-man, reciprocating drill, a wonder in its day, is almost a thing of the past. One-man reciprocating and hammer drills are the machines of the present. Jackhammers for sinking, reciprocating, cradle hammer, and telescopic air feed hammer for driving and stoping; and telescopic air feed hammer for rising, are popular for the duties indicated. The two main types are used to the extent of about 30% reciprocating and 70% hammer, the latter steadily gaining. The design of the newest hammer drills aims at: light weight and small size, automatic rotation, automatic feed, automatic lubrication, drilling speed, water feed, air economy, strength and simplicity, ease of adjustment and repair, and ability to stand rough usage. The perfect drill of the future is likely to approximate to neither of the main types, but to assume the form of a non-vibratory, comparatively noiseless, rotary borer. With the ever-growing command over materials and increasing knowledge of their uses, it is not stretching imagination too far to suppose that some means commercially applicable to the drilling of hard rock more quietly, efficiently, and cheaply than present methods seem ever likely to allow will before long be discovered.

Two very interesting designs of hammer drills embodying automatic rotation now on the market are the Waugh Turbo and the Holman Auto. The former is a cradle machine equipped at the chuck end with an air turbine, which enables the drill steel to be revolved quite independently of the piston hammer. The latter is a telescopic air-feed machine, fitted at the rear end of the extension with an independent reciprocating air motor, which by means of a splined rod oscillates the drill steel. Both of these machines mark a distinct advance in drill manufacture.

The first edition of this book appeared in 1908, and met with gratifying success. The issue of three later editions, each one showing careful revision and embodying useful additions, in the succeeding twelve years has shown that the author is alive to the need of keeping its contents abreast of the times, and that a large circle of appreciative readers are at one with him. Although the general excellence of the treatise precludes much in the way of criticism, a few comments may be offered, in the hope of benefiting future editions. The types of American rock-drills illustrated and described represent the best American practice, but a similar verdict hardly applies to the English machines depicted. No reference is made to the now fairly common adjunct to the large modern mine plant—the air operated drill sharpener. Liquid air would seem to deserve mention in view of its manufacture through the compression and expansion of air, its use in mine rescue apparatus, and its employment as a blasting agent. An amplification of the cost data of plant and operation would be helpful to those who have to inspect the business aspect of the subject; and a bibliography would also be a useful addition.

The attractiveness of the work is enhanced by good quality paper and printing and 258 excellent illustrations, while interest is secured by a scholarly presentation and a blending of theory and empiricism in agreeable proportions.

ALEX. RICHARDSON.

Electrolytic Deposition and Hydrometallurgy of Zinc. By OLIVER C. RALSTON. Cloth, octavo, 201 pages, illustrated. Price 18s. net. New York and London: McGraw-Hill Book Company.

The publication of this book on a specialized subject such as the electrolytic deposition and hydrometallurgy of zinc, so shortly after the proved commercial success of the processes to a study of which it is largely devoted, is an indication of the enormous demand existing at the present time for specialized technical books. The author has undoubtedly done a service to metallurgists in putting on record so promptly many details of the operations involved, and has run the risk of omitting much matter which might have been included had publication been delayed a little longer. Although published only this year, two important papers have already been read since its publication, one describing the electrolytic zinc plant of the Anaconda Company at Great Falls, by F. Laist and his associates, read before the American Institute of Mining and Metallurgical Engineers in February, and the second, read before the Faraday Society by S. Field, describing work done in this country. Both these papers contain a considerable amount of information which might with advantage have been incorporated in the book, and a

knowledge of the matter in these papers makes the reading of the book a little disappointing.

The book contains an excellent history of zinc hydrometallurgy, from which it appears that ever since 1880 serious attempts have been made to place these processes on a commercial basis, but real success was not met with until 1915, when processes were worked out by the Consolidated Mining and Smelting Co. at Trail and by the Anaconda Copper Co. Each developed a simple process of roasting the ores, followed by leaching with dilute sulphuric acid, purification of the solution obtained, and electrolysis to obtain zinc cathodes and regenerate sulphuric acid at the anodes. The purification of the solution was the most important matter worked out, and after the realization of the necessity for this, and by the development of suitable methods and plant for its accomplishment, the electrolytic production of zinc became a commercial success. The roasting, leaching, and purification of zinc sulphate solutions receive attention, and the effect of the presence of the various impurities generally present is dealt with in detail. Cobalt has proved to be one of the most baffling impurities in zinc sulphate solutions, for minute quantities have powerful effects on the re-solution of the cathodes, 10 parts per million seriously impairing the deposition and 15 parts per million being fatal to the process. The work of Hansen, Laist, Elton, Caples, Frick, Hanley, Gepp, Stevens, Snow, Clevenger, and Field in connexion with the purification of solutions is described. The electrolysis of zinc sulphate solutions receives full attention and details of practice on various plants are given.

Although practically all the electrolytic zinc at present on the market is deposited from zinc sulphate solutions, the chloride solution is in use in a few places, and the processes which have been suggested from time to time for the production of the chloride from ores are described, including roasting with salt and chlorination with chlorine gas, chlorination with solutions of metal chlorides, and by-products such as calcium chloride and hydrochloric acid. The chloride of zinc solutions obtained by these processes have many applications in chemical industry, so that, apart from electrolytic treatment, the methods of purification are important and do not differ greatly from the methods used for sulphate solutions. For the electrolytic production of zinc, the chloride solution may be electrolysed as such, or evaporated to dryness and the resulting zinc chloride fused and electrolysed in the fused state. Only aqueous electrolysis is in commercial operation, although fused zinc chloride cells have been tested on a large scale by several different companies, and details as far as available are given of both methods.

To the electrolytic refining of impure zinc, galvanizer's hard dross, and zinc crusts from desilverizing works, one short chapter is devoted, in which most of the important experimental work on these lines is described.

A chapter is also devoted to hydrometallurgical methods used for the preparation of zinc compounds from ores, including ammoniacal leaching, bisulphite leaching, etc., and the manufacture of lithopone, zinc sulphate, and zinc chloride.

In the final chapter the economics of zinc hydrometallurgy are dealt with, and the author is correct in stating that a single chapter (of six pages only) will not suffice to adequately discuss the economics involved in choosing a wet method of zinc extraction in place of the standard fuel smelting process or the electric smelting process. The author concludes that the present state of advancement in the art makes it economical to use electrolytic recovery of zinc only on the more complex sulphide ores, although its application to the treatment of pure ores might have been attractive were it not for the great surplus of smelter capacity in close proximity to such deposits as those of the Joplin district.

C. O. BANNISTER.

NEWS LETTERS

MELBOURNE

March 25.

MINING CONDITIONS IN AUSTRALIA.—Mr. M. A. Davidson, M.L.A., chairman of the Select Committee appointed by the New South Wales Government to inquire into the decline of metalliferous mining in the State, has issued an interim report based on the committee's inquiries in Armidale, Emmaville, and Tingah districts. The report refers to the fact that, unlike other industries, increase in the cost of production in the metalliferous mining industry cannot be passed on. For this reason it is urged that special support should be given the industry

by the State Government, which should fix the price of base metals commensurate with the cost of production, and hold the metals in reserve until the market value has revived. As an alternative, it is suggested that an advance on the amount of base metals produced should be made to companies which had not previously made large profits. The export embargo, imposed during the war, is deemed to be now unnecessary, and its immediate removal urged, while it is recommended that the State Government should take into immediate consideration the advisability of a modern plant established in a central position for the treatment of ores in Australia, instead of shipping them abroad. Greater encouragement of prospecting is advocated, by increasing the amount of financial aid and assisting in the establishment of treatment plants. A geological survey of the metalliferous areas of the State, it is urged, should be undertaken, as early as possible, and the geological survey staff increased to ensure its rapid completion. Light railways linking up with main lines and improved roads are stated to be an urgent necessity, while it is stated that the continually increasing freights, railways and otherwise—which increases cannot be passed on—have been a great factor in the closing down of some of the smaller and low-grade mines, and a general flat rate, greatly reduced, for ores, is recommended. The report concludes by stating that a proper system of organization is required, and asks : is it preferable to allow mines to close down and the employees to drift to the city and cause a big increase in the already huge amount that is being spent by the Government in relieving distress, or to place the amount of money into the industry, thereby reviving the production and eventually obtaining a refund of the money now being spent.

Last week-end the Select Committee took evidence in Broken Hill. The first witness was the mining warden, Mr. A. R. Perry, who has had experience in several parts of the State. He had, he said, noticed a great falling off in the number of prospectors, which he considered to be due to the unremunerative nature of the occupation. Broken Hill was a rich man's field, and the poor man had little chance. The prospector should be protected and encouraged to the uttermost. A small treatment plant would help prospectors considerably. Mr. W. Riechers, who had prospected in the district for six years, said that he worked for lead, zinc, and silver at the Allandale mine, where he erected a concentrating plant, capable of treating ten tons a shift. It had given good results, and the costs were very moderate. He would like to see a small concentration plant put by the Government near the railway for the benefit of prospectors. Its cost need be only about £3,000 or £3,500. It did not pay prospectors to send crude ore away, because of the heavy freight charges. Witness was interested in a mine at Thackaringa. He produced a general sample of zinc ore, which would assay about 61%. There was no market for the zinc, because of the Federal Government's ten years' contract with the British Government. The small men had no market. The Federal or State Government should find a market for the small producers.

Thomas Ham, underground manager at the Junction North mine, gave some interesting particulars about the tinfield at Euriowie. If there was a portable battery there, he said, much more work could be done, and the place could now carry, at the present price of metals, 150 to 200 men instead of being idle. He had worked at one mine at Euriowie 32 years ago, and he did not think that anyone had worked there since. There was good tin there. He had seen a lode from 10 ft. to 30 ft. wide. Witness did think that the Broken Hill mines could work at a profit at the present price of metals. From a show at White Cliffs, witness sent some ore to the Wallaroo smelters that showed 32% copper, but the smelting charges were 8s. a unit. There was also gold in the ore. The show was now lying idle ; he could not touch it, because of the low price of copper. He considered it absolutely essential, for the good of the industry, that prospectors should be helped. The Prospectors' Association favoured the creation of local prospecting boards, said this witness, and the increasing of the powers of the local wardens, to obviate the long delays caused through everything having to be done through Sydney. Witness did not believe that anything payable had been found outside the known line of lode for 25 years.

Early Ice Ages.—Discoveries of evidence of glaciation on igneous rocks of Carboniferous age have recently been made in the Maitland district, New South Wales, by Mr. W. R. Browne, a lecturer in the geological department of the Sydney University. Professor Sir Edgeworth David has discussed these discoveries at some length in popular language, and the substance of his remarks

is given herewith, without omission of the explanatory portions intended for the layman.

Prior to this discovery, surfaces of granite rock, grooved and striated by the movement of a glacier ice, have been described as occurring on the Kosciusko Plateau. These ancient glaciated pavements at Kosciusko were worn down and grooved by the ice at a period probably some 10,000 to 50,000 years ago. The special interest attaching to this new discovery is that it is evidence of a far older glaciation, dating back to some 250 millions of years ago. This period, known as the Carboniferous, somewhat antedates the epoch of the oldest coal measures in Australia, namely, the Greta coal measures of the Lower Hunter region. There is evidence that glacial conditions were prolonged at intervals for some time after the formation of the Greta coal measures had been completed, but just previous to the deposition of the Newcastle-Bulli-Lithgow coal measures with the underlying Tomago coal measures. Thus the Greta coal measures of New South Wales, in which the most productive collieries of the northern coalfields are at present situated, belong to an interglacial epoch of this extremely ancient ice age. Glaciated rock pavements somewhat similar to that just discovered, have been recorded from Bacchus Marsh and Derrinal, near Heathcote, in Victoria, Hallett's Cove, and the Inman Valley to the south of Adelaide. In West Australia, although no glaciated pavements have yet been found, there is abundant evidence of the existence there of glacier ice at this Carboniferous period. The evidence of the Irwin coalfield in West Australia is in the form of huge boulders of rock, foreign to the district, up to as much as 60 tons in weight, many of these blocks being scratched and grooved by the old ice-sheets which have used them as "holystones" in the process of grinding down and polishing the rocky floor beneath the ice-sheets over which the thick ice was slowly creeping and exerting enormous vertical and lateral pressure.

Both in West Australia and South Australia there is evidence that the ice-sheets and icebergs ranged northwards to about the parallel of 25° S., that is, within a few degrees of the Tropic of Capricorn. In fact, during this Carboniferous period the whole of Tasmania and the greater part of the southern half of Australia must have been very much in the condition of the South Polar lands to-day. Probably the whole surface of the country within the area specified was covered by glittering sheets of thick ice, with the exception of a few of the higher peaks, such as the great volcanoes of the period, developed on a grand scale in the Lower Hunter region. These erupted glowing masses of lava and grey to green layers of volcanic ash amid the snow and ice of the period, just as Mount Erebus and other active Antarctic volcanoes do to-day. The same exquisite tints of sapphire blue were doubtless to be seen in the crevasses of these very ancient ice-sheets, and the same lovely tints of emerald green around the margin of their floating bergs were doubtless to be observed then as in Polar regions to-day; and in the seasons of summer thaw great rivers sprang into being in a few days and rolled the rock debris of the great volcanoes down into the moraine lakes, and to the margins of the ice-sheets, while the roar of intermittent volcanic eruptions mingled with the thunder of the great avalanches, like those one so often heard and saw rushing down the steep slopes of the Antarctic Andes into Ross Sea.

Previous to this recent discovery near Maitland, the existence of these glaciations before and after the formation of the Greta coal was well known, and an excellent summary of the evidence has been given by Mr. C. A. Sussmilch in a paper published by the Royal Society of New South Wales last year. In the case of evidences of the passage of these ancient ice-sheets over Victoria and South Australia it is possible to determine the direction of movement of the ice by means of the trend of the grooves on the rock floor over which the ice moved, and it may be said that the grooves run generally in a northerly and southerly direction. It remained to decide the "sense" of the movement, that is, whether it had been from south to north or from north to south. In the case of ruts made by wheeled vehicles, one can tell the general direction in which the vehicles have been travelling by the trend of the ruts; but in order to determine the sense in which any particular vehicle has been moving one would have to study the ruts in conjunction with the impression of the horses' hoofs. The latter would at once give the sense of the movement.

In the case of the movement of glacier ice, the place of the hoof-marks, as in the above illustration, is taken by small pieces of rock which have been dragged loose or plucked

by the moving sheet of ice. Thus, small recesses are left where these fragments of rock have been forced off, with little vertical cliffs facing the direction towards which the ice has moved. No such small cliffs with sharp edges could possibly exist if they were opposed to the direction of movement of the glacier ice, as in that case they would rapidly be ground down and obliterated. Another proof as to the direction of movement of ancient ice-sheets is to be found in the character of the large blocks of rock, foreign to a neighbourhood, and known as "erratics". Such blocks have been transported from a distance on top of the ice-sheet or floated by icebergs. It is often possible to discover the exact locality from which such "erratics" have been derived by this method. In the case of the glaciation which followed on after the development of the Greta coal measures, a study of the large erratics found near Branxton shows that they were probably derived from mountains in the neighbourhood of Mount Lambie and the Jenolan Caves.

In regard to the earlier phases of this very ancient Carboniferous glaciation—the phase which preceded the Greta coal measures—the test of the direction of movement of the ice by means of a study of the erratics is inconclusive. The discovery just made by Messrs. Osborne and Browne shows conclusively the exact direction from which the ice came, for not only are there thousands of more or less parallel grooves and scratches on the galciated rock surface at Rockdale, but there are structures, corresponding to hoof-marks, as referred to above, which show the sense in which the ice moved. It came from a little east of south and moved towards a direction north by west.

It would thus appear that the margin of the great continental ice-sheets of Australia in Carboniferous time was situated in New South Wales, near to, or possibly in, what is now the Hunter Valley, extending thence to Currabubula, near Tamworth, and beyond. There is a great development, near the recently discovered glaciated pavement, of the fine-grained flour of rock representing extremely finely pulverized material carried out from under ice-sheets by their sub-glacial streams, and deposited as fine mud in glacial lakes dammed back by mounds of moraine rubbish along the margin of the ice-sheets. These rocks occur usually in delicate paired layers, in some cases as many as from 50 to 100 of these paired layers being counted in a thickness of 1 ft. of rock. The two layers in each pair are of unequal thickness. The thicker layer was deposited by the floods resulting from the summer thaws, and frequently contains small fragments of plant stems and fronds of ferns. The thin member of each set of pairs was deposited during the winter, when the ground was frozen and covered with snow and ice. No remains of plants are found in these thin layers. By counting these paired layers in a given thickness of rock it is possible to tell exactly how many years have been occupied in the deposition of these particular strata. It is estimated that the thickness of about 300 ft. of shales found near West Maitland have taken about 5,000 years to form.

The distribution of the great Carboniferous continental ice-sheets of Australia and Tasmania largely explains why the productive coal measures of the great coal basin of New South Wales appear to be entirely wanting from South Australia, the greater part of Victoria, and Tasmania, as well as from the southern part of West Australia. These southern regions continued to be glaciated long after the edges of the continental ice-sheet had withdrawn from the region of the northern, western, and eastern coalfields of New South Wales, as well as from the region of the Irwin River in West Australia. In areas on the equatorward side of the retreating continental ice-sheet, extensive coalfields of vast value became developed.

PERTH, W.A.

April 24.

Whim Well.—The gold and copper mines of what is generally referred to as the Nor-West were discovered by prospectors returning from the Kimberley rush before the dawn of the eastern goldfields. Metallurgical difficulties in the treatment of the ores, and the scarcity of fuel and timber, have hitherto been against the successful working of the mines on the Pilbara field. However, the rapid decline in the gold-mining areas further south (Murchison and Kalgoorlie) has caused attention to be drawn to the possibilities of the Nor-West. Miners and prospectors are wending their way up, and if the Government will only reduce the heavy taxation and custom dues. many mines will be worked to a profit, The introduction of suction gas plants has made a great difference in the cost of power, especially, as in the case of Whim Well

mine, where fuel has to be imported by boat from a southern port.

On the treatment side two processes have been introduced recently that will help to overcome the difficulties that have militated against the success of this field. The first is the introduction of leaching of the low-grade oxidized ores of copper, while the second, as yet in its trial stages, is the economic extraction of gold in the presence of small quantities of copper, which latter have prevented a good extraction from being obtained by amalgamation and cyanidation. I do not propose to discuss this in the present paper, because sufficient information is not available to the public at present. The question of leaching has been proved to be successful on the Whim Well copper mine, and it opens up big possibilities not only for this mine, but also other similar ore-bodies in the Nor-West.

The Whim Well is the largest copper-ore deposit in the Pilbara field, and a description of it may be of interest. It is situated 56 miles by road to the east of the port of Roebourne, the administrative centre, and 12 miles south from Balla Balla on the coast. There is a tram-line connecting these two points and extending another mile to a safe harbour for lighters. The picked ore and copper are thus railed from the mine, loaded on to the latter, which take them out 7 miles to a well-protected anchorage, there transferred on to boats doing the coastal trading from Fremantle to Singapore. The ore is sent to smelting works in the eastern states or England.

The Whim Well mine was worked intermittently by prospectors for several years, who broke out about 10,000 tons of 15% copper ore, of which they shipped about 4,000 tons averaging 26%. In 1906 the Whim Well Copper Mines, Ltd., took up the property, but had very little capital available. During the following eight years 132,000 tons of 8½% copper ore were broken, of which 57,000 odd tons of 14% average were shipped, while 75,000 tons of rejects of about 4% average were put aside until a suitable treatment became available. During this period a Murex concentration plant was erected for the treating of low-grade oxidized ore. Owing to a number of circumstances it was not an economic success, although an extraction of 80% on 4¾% copper ore was obtained. From 1914 shipping space became very difficult to secure, and not much was done until 1917, when attention was drawn to the successful work being carried out in the leaching of 2½% copper ore at Mount Hope (New South Wales). Experiments were carried out, and in 1920 a start was make to leach a heap of 40,000 to 50,000 tons 4% ore by means of a leaching process known as the Peechy, which will be described later.

The geology has been described in bulletins of the Geological Department, and also in a paper read before the Institution of Mining and Metallurgy on December 21, 1911, by Mr. H. R. Sleeman. I need not describe the geology otherwise than by saying that the ore deposit occurs in grey slaty country which is replaced to the north by schists (altered sediments), which in turn are replaced by earthy travertine limestones, extending to the coast-line. The latter are flanked east and west by extensive granite areas. The ore-body strikes roughly east and west for 3,000 ft. along the crest of a ridge, eventually dipping under the alluvium. The dip is flat (20°) to the north, while there are a number of cleavages running N.W. and S.E. of apparently the same period as the ore-body, as it has not been faulted by them. Along the lines of cleavage, even outside of the main ore-body, copper has been carried in solution and deposited. Typical ironstone gossan overlies the ore deposit, which was no doubt originally pyritic to the surface. The oxidation of the chalcopyrite has left the iron as a capping, while the acid solutions have kaolinized the slate beneath, in which the copper has been deposited as carbonates, oxide, and silicate, with some secondary chalcocite. Owing to the flatness of the ore-body, this action has apparently been local, and there are no lines of ore deposition as shoots. Rich ore has been mined right from the outcrop to the lowest points worked, about 120 ft. below the lowest adit level. At these lowest parts the rich ore is going down as of equal grade as the best parts mined above it.

The development work in the past has been done essentially for the winning of high-grade ore for shipment, and only certain areas have been exploited at all. The result is that it does not lend itself to the estimation or ore reserves in the accepted use of the term.

Mr. H. R. Sleeman has been in charge of the operations for some years, and by his experience of the law of the average value of the faces and level bottoms, together

with the assays from diamond-drill bore holes, he feels justified in estimating the amount of possible ore as a million tons, containing 4% copper. From the outcrop along the line of dip to the vertical depth of 150 ft. below the lowest adit level is 1,000 ft. The main workings extend over a length of at least 600 ft., while the ore-body varies in width from 10 to 50 ft. The total mining to date amounts to 200,000 tons of 8% ore (including pillars left), so that the estimate of the possible amount of pay ore (4%) left in the mine to the bottom level gallons per day of 24 hours, 10,000 gallons were needed for make-up in new parts of the dump at first. The loss was reduced to 4,000 gallons after the circulation was started, and when more complete draining of the dump had been effected. A circulation of twice the above is necessary to make the dump leaching payable. It has been found that 70,000 gallons in circulation will return 10 tons of copper precipitate per month, but with the improvements now effected it is expected that 20 tons per month will be secured by heap leaching, utilizing a

WHIM WELL COPPER MINE.
Vats for experimental work in leaching in the foreground.

is more than twice the amount already taken out.

Hitherto this grade of ore has been unpayable, so that the richer portions have been taken out, while the low-grade ore has been dumped or left in the mine. The experiments carried out for heap leaching were made by Mr. Audley Smith and the mine staff, on the lines of the treatment at Mount Hope, New South Wales. A start was made in 1920 on a 50,000 ton dump of ore, containing 4% copper. A fairly satisfactory result was obtained, but the loss of water was greater than the supply in the mine. It was found that to maintain a circulation of 70,000 circulation of 150,000 gallons of water per day with a loss of 7%. Thus the question of water is a very important one, and an engineer of the Mines Department has recommended that the mine warrants the erection of a five-inch pipe line from Balla Balla to the mine to provide the water necessary for heap leaching, concentration, and leaching of the current ore. The present plant on the mine will be adapted and where necessary expanded to carry out the following treatment scheme, which is based on experiments made.

The ore from the mine is conveyed on a belt to the breaker, from which any high-

grade ore is picked by boys. From there it passes on to rolls crushing to ¼ in. mesh. It is then hydraulically classified, the sands going on to a May jig for concentration, and from thence through an 8 ft. Hardinge pebble-mill, the product going to the agitators with the overflow from the classifier. The fine product is then agitated and leached in Brown agitators with sulphurous acid gas and air from an air-lift, and decanted on the counter-current system used on the gold-fields. As the copper in the solution increases to a suitable percentage, it is sent to the precipitation tanks, which are filled with scrap iron. The excess wash solutions can be used on the heap leaching plant whenever required. The concentrate will be kept up to 20% copper, while the precipitate assays 70% copper, which will be shipped to the most suitable smelters. At the present time the SO_2 is generated from sulphur, but it is intended that before long it will be obtained direct from the pyrites, which has been proved to be of considerable extent below the present workings. The pyrites may also be used on the top of the ore dump, as is done at Bisbee in America, for the rejuvenation of the solutions, thereby increasing their leaching value.

Should this joint scheme of treatment prove up to expectations, it will pave the way for similar work on other copper mines in West Australia, which have hitherto been unable to get a sufficient ratio of shipping ore to that of the low-grade material now shown to be amendable to treatment by leaching.

C. M. Harris.

TORONTO

June 13.

Porcupine.—The gold-mining industry is showing increased activity. The producing mines are increasing their output, much capital is seeking investment, and new properties are being opened up. Attention is being directed to the outlying territory beyond the known gold-producing area, where considerable exploration is being carried on. The Hollinger Consolidated is producing gold at the rate of approximately $200,000 per week, the extraction averaging about $9 per ton. The company has decided to develop its own electric power, and is proceeding with a preliminary survey of the Kettle Falls on the Abitibi River, where it is estimated that 25,000 h.p. may be generated, in addition to 10,000 h.p. reserved by the Ontario Government. The falls lie about 60 miles north of the mine, and the intervening territory presents no serious obstacles to power transmission. The annual report of the Dome Mines for the year ended March 31 shows a considerable reduction in profits due to the unfavourable conditions during the early part of the twelvemonth. Bullion was produced to the value of $1,946,495, the average yield per ton treated being $7·11. The net profits were $302,479, as compared with $951,984 in the preceding year. Operating costs for the first quarter of 1921 went up to $5·05 per ton owing to power shortage, dropping to $3·75 when power again became available in April. General manager Depencier in his report stated that while he regarded it as futile to estimate the value of the ore reserves the developments on the 10th level were considered of extreme importance, as proving the occurrence of highly payable ore at the lowest level opened up. The stamp equipment of the mill, which has not been used for some years, has been put in order for operation, bringing the capacity of the mill up to 1,400 tons daily. The McIntyre has placed an order for an Hardinge ball-mill and other equipment, which will be installed in the fall, bringing the capacity of the mill up from 550 to 900 tons daily. The Hollinger Reserve, lying west of the Hollinger Consolidated, where a high-grade vein system has been opened up at the 300-ft. level, has been purchased by a syndicate headed by E. A. Osler & Co., of Toronto, and development will shortly be commenced. The Goldale Mining Co., which has taken over the Bewick-Moreing holdings, is arranging to carry on an extensive exploration campaign. The North Crown Mine has closed down indefinitely, and it is understood that further financing will be necessary before resuming operations. The Tommy Burns property, about 10 miles south-east from the producing area of the camp, has been taken over by the Triplex Gold Mines. The workings are being unwatered and a new shaft is being put down. Operations have been resumed at the Premier Paymaster, where diamond-drilling has proved the eastward extension of the main vein.

Kirkland Lake.—The Lake Shore during April recovered bullion to the value of $22,213 from the treatment of 1,860 tons of ore, being an average of $11·94 per ton. The mill is kept running on development ore, the policy of the management being to store

up large ore reserves in anticipation of the enlargement of the plant. The Tough-Oakes has resumed underground work with the expectation of commencing milling about August. An important discovery has been made at the 900 ft. level of the Kirkland Lake mine, where horizontal drilling has encountered about 12 ft. of highly mineralized material, 9 ft. of which carries high gold content. A large new ore-body is being opened up at the 700 ft. level. At the Ontario-Kirkland the construction of the mill is making good progress, and it is hoped to have it completed in September. About 3,500 ft. of lateral work has been done on the 300 and 450 ft. levels, indicating a supply of ore sufficient to keep the mill running for three years. The vein at the 100 ft. level of the King Kirkland has been opened up for 172 ft., a considerable proportion of the ore assaying $10 to the ton. Surface exploration is being carried on to determine the most favourable place for sinking a central shaft. The shaft of the Bidgood is being unwatered, and will be put down from its present depth of 300 ft. to deeper levels. A shaft is down 60 ft. on the Lebel Oro on a vein stated to show ore averaging $18 per ton over a width of about 40 inches. A 10 ft. vein carrying good gold content has been found on the Moffatt Hall property, 5 miles from the Tough Oakes. A large syndicate, mainly representing English interests, is bidding for numerous properties lying along the line of the north-easterly strike of the proved gold-bearing zone. Individual claim-holders have been approached with attractive offers for options, and some of the new companies have been offered good prices for their holdings.

COBALT.—Though silver-mining is still depressed by reason of the low price of the metal, conditions are showing some improvement. Towards the close of May the Mining Corporation of Canada resumed operations at full capacity, giving employment to about 250 men. Since closing down the company has increased the capacity of its mill by about 50%, enabling it to treat a higher tonnage and reduce operating costs. The annual report shows profits of $579,569, as compared with $908,748 in 1919. Silver was produced to the amount of 1,664,018 oz., as against 1,230,652, and the ore reserves showed a satisfactory increase, being estimated at 2,181,000 oz., as compared with 1,307,220 in 1919. The amount to the credit of the profit and loss account was $3,268,628. The company covered a wide field in its search for desirable properties, and during the year had about 300 under its consideration. Permanent records embracing 165 of these were prepared, of which 132 were in Canada, 56 of the number being in Ontario, indicating that the Dominion will continue to be the principal scene of its activity. The Peterson Lake, which sustained a considerable loss on last year's operations, and is confronted with heavy obligations, is endeavouring to reconstruct its finances. Its ore reserves are estimated at 126,000 oz. of silver, and the directors believe that if funds for further development can be secured there are good prospects for additional ore discoveries. An important discovery has been made on the Oxford Cobalt, where a number of stringers, one of them carrying 600 oz. of silver per ton, have been encountered 6 ft. below the surface. The O'Brien produced 312,000 oz. of silver during May from the treatment of 6,066 tons of ore, showing an average recovery of over 51 oz. per ton. Lateral work on the Chambers-Ferland property of the Kirkland Lake Proprietary (1919) has encountered an important ore-body averaging 50 oz. of silver to the ton.

VANCOUVER, B.C.

June 9.

GRANBY CONSOLIDATED. — The Granby Consolidated Mining, Smelting, and Power Company has just issued its annual report for 1920. As with the great majority of the other copper companies on the continent, the year has been an unprofitable one, the report showing a deficit of $687,011, which compares with a deficit of $984,409 in 1919. There is this unfavourable difference, however, that in 1919 the company disbursed dividends amounting to $1,312,537, while last year no dividends were declared. The assets of the company were reduced from $25,081,361 to $24,906,360, and the surplus from $1,184,309 to $497,298. The ore-reserve, too, suffered a depletion of 200,000 tons. The last is explained by the fact that in the early part of the year, when the price of copper was good, effort was concentrated on production, at the expense of development. As soon as the 150 ft. level has been enlarged to allow of development to be carried on without hindering production, the boundaries of the ore-body will be extended.

During the year the company produced 25,744,327 lb. of copper, 1,054,206 oz. of silver, and 9,481 oz. of gold. The great

bulk of the silver, probably over 90%, came from ore purchased from the Dolly Varden mine. This ore, which is highly siliceous, acts as a flux for the company's Hidden Creek ores. The average cost of the production of the copper was 15·94 cents per pound, and the average selling price for the 19,464,796 lb. of copper sold was 17·85 cents. Considerable economies were introduced during the latter half of the year, after the change in the management, the cost of production for the first half of the year being 18·38 cents, and for the last half 14·01 cents. Since last fall two cuts have been made in the wage scale, totalling $1·25 per man per shift, and a further reduction in the cost of production has been made this year, the cost for the month of March being 12·44 cents. This reduction is due to increased efficiency on the part of the men, and to improved metallurgical practice, resulting in the use of less coke and flux and in improved extraction,

A. J. Bancroft, professor of geology at McGill University, has taken up his new duties as assistant general manager for the company, and among his first duties will be the extending of the ore-reserve, which now totals 10,986,430 tons of smelting ore. The Governors of McGill University have given Professor Bancroft a year's leave of absence, in which he will decide whether he will take up technical work as a profession or return to pure science at the university.

The company's Cassidy colliery produced 154,000 tons of coal during the year, of which 30% was sold and the remainder converted into coke at the by-product coke-ovens at Anyox, resulting in the production of 75,000 tons of coke. Improvements have been made in the coal-washing plant, and a better grade of coke is being produced.

Standard Mine.—The directors of the Standard Silver-Lead Mining Company have announced that, subject to ratification by the shareholders at a meeting to be held on June 20, they have sold the company's Standard mine for $75,000, of which $25,000 is to be paid in cash and the balance in two equal instalments at one and two years, respectively. A royalty of 20% is to be paid on all ore shipped from the property, such moneys to go towards the purchase of the property. The directors consider that for big-scale operations the mine is worked out, and for the past year it has been in the hands of lessees. The Standard has been an excellent mine, and has payed its shareholders more than $2,700,000 in dividends. The company is in a strong position. If the present sale is consummated it will have a surplus of more than half a million dollars; this is being held for investment in the mining industry in the province, provided a property satisfactory to the directors can be found. It is understood that several properties are under consideration at the present time.

Nickel Plate Mine.—The Hedley Gold Mining Company, owners of the Nickel Plate Mine, at Hedley, has issued its annual report, which shows a deficit of $1,941 on the operations last year. The company realized that the mine was running behind, and, as no satisfactory terms could be made with the employees with regard to a reduction in wages, the mine was closed early last autumn. During the war effort was concentrated on production, and the development, which up to then always had been kept well ahead, was allowed to run behind. Diamond-drilling has indicated that there are extensive ore-bodies awaiting development, and the directors have decided to spend $35,000 in opening up the property for production. The wage scale has been reduced $1·25 per day, so that this work can now be done at a reasonable price.

Premier Mine.—Though the price of labour has been reduced in practically all the mining districts of the Province, the employees at the Premier mine refused to accept a reduction, and on the company attempting to enforce it went on strike. The strike extends to all departments, and includes the work on the concentrator and on the aerial tramway. The company attempted to make a reduction of only 75 cents per day in the wage scale, while $1·25 has been the amount of the reduction in nearly all other parts of the Province. Even if the reduction had gone into force, this would have been the highest priced mining camp in the Province: miners would have received $5·50, shovellers $5·00, and surface labourers $4·75 to $5·00. This is a dollar per shift more than the present rate in the Slocan camp. After being on strike for two weeks the men took a ballot, the result of which was for continuing the strike by a majority of four to one.

Slocan District.—With a view to bringing about renewed activity in the Slocan, the principal silver-lead mining district in the Province, the local branch of the International Mine, Mill, and Smelter Workers met the principal operators and

agreed on a new wage scale, which is a reduction of \$1·25 per day on all classes of labour. Miners and skilled mechanics are now getting \$5·00 per day, mechanics' helpers \$4·50, and labourers and shovellers \$4·00. The result has been that a number of the mines either have restarted operations or are about to restart. The Silversmith Mines, Ltd., owning the principal mine in the district, has made arrangements with the owners of the Ivanhoe mill, by which the Silversmith has acquired the mill, mill-site, and water-rights on the south fork of Carpenter creek. The mill is being overhauled and its capacity brought up to between two and three hundred tons per day, according to the nature of the ore milled. An aerial tramway is to be built to connect the Silversmith with the mill. The mine was closed down on April 1, sufficient ore having been developed to assure a supply for some time. Effort now will be concentrated on the remodelling of the mill and on the building of the tramway, and when this has been completed it is probable that the mine will be reopened.

The Yukon.—Several hundreds of tons of supplies, mining machinery, and building material are accumulating at Whitehorse for shipment to the new silver-lead camp at Mayo. It is expected that the river will be in condition for moving this towards Mayo Landing by the end of the second week in June. The Yukon Gold Mining Co. and the White Pass Railway Co. are building wharves at Mayo Landing.

Alberta.—A bill has passed the Dominion House providing for the incorporation of the Mackenzie River Railway Company, Ltd., with a capital of \$10,000,000. It is understood that the Imperial Oil Company is substantially behind the project. The railway will extend the Alberta and Great Waterways system from Fort McMurray, where the rails now end, to Great Slave Lake.

Considerable excitement has been caused by the discovery of alluvial gold in the banks of the creek running into the Cadotte river, which flows into the Peace river about 40 miles below Peace River town. The new discovery is 75 miles from Peace River town. The original discovery was made by an Indian trapper, who brought nuggets into the town. Dr. Gauthier and a party set out for the location, and after doing a little excavating and panning were convinced with the value of the discovery, staked claims, and filed them in the land office at Peace River.

LETTERS TO THE EDITOR

Wave-transmission Rock-drills

The Editor:

Sir—I note that Mr. Chas. R. Love objects to the loss in the transmission cables which I had assumed in my comparison between the boring capacities of the wave-motion rock-drill and the pneumatically operated tool per i.h.p. installed at the surface.

This matter has very little bearing on the point at issue, and the loss in transmission can be reduced to any reasonable extent by increasing the sectional area of the conductor employed, the cost of the cable being the only factor of commercial interest.

Similarly, Mr. Love may certainly generate the current at the voltage he prefers, and thus do away with the necessity for the use of underground transformers, but I hold that it is not good commercial practice to use low voltages in transmission lines, owing to the great cost of the extra copper required in the conductors. The voltage might easily be reduced to one-half, one-quarter, or one-tenth of that which I should propose to use (3,000 volts), but in that case the cost of the cables will have to be multiplied by two, by four, or by ten, as the case may be, and even in the very limited area of a mining concession, the extra expense will be a formidable item.

With regard to Mr. Love's statement that I have been comparing a wave-power plant of 12 h.p. with a compressed-air plant of 1,000 h.p., I must protest altogether, and I think that Mr. Love has overlooked a certain very important difference between the two systems.

If the pneumatic system is to be installed on a mine, the whole compressing plant may be set up at any convenient place and the compressed air led to any workings within the limits of the property without regard being paid to the lateral extent of the workings or to the differences in altitude between the compressor and the rock-drills which have to be operated by it.

It is quite otherwise with the wave-power plant, as the generators and the drills which they are to operate must be installed within reasonable lateral distance of each other, and it is essential that the difference in vertical height between the wave-motion generators and the rock-drills must be strictly *limited.*

This means that any ordinary mine would require many separate installations at various depths in each shaft in which the drills are required. The wave-motion generators must therefore be constantly moved from place to place and this calls for small units which must be easily transportable.

Certainly bigger units than 12 h.p. each might be used if they can be built sufficiently compact, and not too heavy for easy transportation *in the shafts*, but I am not aware that anything larger than the 12 h.p. unit has, so far, been built, nor do I see outside the somewhat better efficiency of the larger electric motor which would be required, any real advantage to be gained, as there is no reason to expect the efficiency of the wave generator to be increased to any serious extent by doubling or trebling its capacity.

Since the compressed-air installation does not call for subdivision into small units, the case of the 12 h.p. air-compressor does not arise, and I can only repeat that, in my opinion, the wave-power rock-drill is not a serious competitor to the compressed-air drill for mining purposes from any point of view.

In conclusion I must deny that I have treated the wave-motion system at all unfairly in my previous letter; in fact, I consider that I have been more than generous to it by crediting it with a boring speed very much in excess of that which I believe it to be capable of, nor have I touched upon certain other disadvantages which I believe to be inherent to the system, and which would surely cause trouble and inconvenience in ordinary mining use.

R. DE H. ST. STEPHENS.

Camborne, *June* 25.

PERSONAL

REGINALD F. ALLEN is now engaged at the Kingsdown (Hewas Water) tin mine, St. Austell.

E. C. ANDREWS, Government Geologist for New South Wales, has been elected president of the Royal Society of New South Wales.

ERNEST BOTTOMS is home from Nigeria.

SIR JOHN CADMAN has been elected president of the Institution of Mining Engineers.

J. MORGAN CLEMENTS has returned to New York from China.

F. G. COTTRELL is in Europe investigating helium and oxygen production on behalf of the United States Bureau of Mines.

N. F. DARE has been appointed manager for the Chenderiang Tin Dredging Co., Ltd., in Perak, Federated Malay States.

ALLAN DAVIDSON has returned from Nigeria.

ARTHUR DICKINSON is back from Brazil.

R. W. FFENNELL has returned to South Africa.

T. R. HAMBLER is home from Nigeria.

R. W. HANNAM is home again from Nigeria.

Dr. J. A. L. HENDERSON has moved his office to College Hill Chambers, College Hill, Cannon Street, London, E.C. 2.

JAMES HOCKING has returned from Spain.

ARTHUR W. HOOKE has gone to the United States on a short visit. As representative of Inder, Henderson, & Dixon, he will inspect some alluvial gold deposits in the Seward Peninsula, Alaska.

ALFRED JAMES has resigned from the Council of the Institution of Mining and Metallurgy.

FRED JOHNSON has been elected president of the Birmingham Metallurgical Society.

RICHARD L. LLOYD, of the Dwight & Lloyd Metallurgical Company, has been awarded the degree of Master of Science by the Washington University, St. Louis, U.S.A.

ROSS MACARTNEY is expected from Rhodesia.

S. M. MARSHALL has returned to New York from India.

JOHN MATHIESON and the other members of the Scottish Spitsbergen Syndicate's expedition arrived at Spitsbergen on June 16.

WALTER G. PERKINS has returned to his old address at 62, London Wall, London, E.C. 2.

ALEXANDER RICHARDSON is leaving for Canada and the United States, where he will visit mines and mining schools.

SIR MARCUS SAMUEL, head of the Shell Group, has been made a peer, and is now known as Lord Bearsted.

EUGENE SCHNEIDER, the iron-master of Creusot, France, is to be the John Fritz medallist for 1922.

W. E. THORNE has left for Nigeria.

W. D. THORNTON has moved his office to the new Cunard Building, 25, Broadway, New York.

J. R. THURLOW is here from the Rand.

R. P. TOD, who has been for many years in charge of the British Aluminium Co.'s works at Kinlochleven, has joined the staff of Sir W. G. Armstrong, Whitworth & Co., Ltd., where he will be occupied with the firm's hydro-electric work.

LOUIS A. WRIGHT is on a short visit to Spain.

The summer meeting of the Mining and Metallurgical Golfing Society was held at the links of the Highgate Golf Club on June 28. The first prize was won by EDWARD HOOPER (90 − 11 = 79 net) and the second by W. H. STENTIFORD (100 − 16 = 84 net).

ARTHUR L. PEARSE died at New York on May 14.

SIR BERNARD OPPENHEIMER died on June 12, after having been in indifferent health for over a year. He was head of the South African Diamond Corporation. It will be remembered that he established several diamond cutting works in this country, where he employed disabled soldiers.

SIR THOMAS WRIGHTSON, BART., chairman of Head, Wrightson & Co., Ltd., Stockton-on-Tees, died on June 18, aged 82. He was born in 1839 near Darlington, and received his education at King's College, London. He served an apprenticeship at the Elswick Works, Tyneside, of which his cousin, Sir William G. Armstrong was then the head. He also spent some time in civil engineering at Westminster with Sir John Fowler and Sir Benjamin Baker. In 1864, he went to the ironworks of Head, Ashby & Co., Stockton, which shortly after became known as Head, Wrightson & Co., Limited. He contributed many papers to the proceedings of the

Iron and Steel Institute. He was interested in many other departments of science than engineering and steel manufacture. His work in connexion with the physiological theory of hearing and the structure of the ear was of high order and was well received among physicists and in medical circles.

TRADE PARAGRAPHS

SALTERNS, LTD., of Parkstone, Dorset, send us a pamphlet on the development of water power, describing their water turbines and accessories.

The GENERAL ELECTRIC Co., LTD., of Magnet House, Kingsway, London, W.C. 2, send us a pamphlet describing the "Kingsway 11" miners' electric hand-lamp

The CRESSALL MANUFACTURING Co., of 40 and 41, Staniforth Street, Birmingham, have issued a leaflet describing their controller resistances for cranes, lifts, hoists, etc.

THE CONSOLIDATED PNEUMATIC TOOL, Co., LTD., of 170, Piccadilly, London, W. 1, send us leaflets describing electric grinders, air and electrically operated coal drills, and the Boyer hammer-pick.

JOHN MILLS & Co., of the Railway Foundry, Llanidloes, Montgomery, send us a catalogue relating to their steam-driven self-contained hauling engines. The catalogue contains full illustrations and descriptions of the standardized spare parts.

BRUCE PEEBLES & Co., LTD., manufacturers of electrical machinery, Edinburgh, announce the appointment of Arthur T. Smith as their representative in the Midland Counties of England, and of Harold E. Webb as their London office manager.

THE MITCHELL VIBRATING SCREEN, invented by B. A. Mitchell, chief engineer to the Utah Copper Company, is being placed on the market by the Stimpson Equipment Company, of Salt Lake City, which is represented in the country by Stephen M. Holden, 42, Bannerdale Road, Abbeydale, Sheffield.

THE WESTINGHOUSE ELECTRIC INTERNATIONAL Co., of 165, Broadway, New York, and 2, Norfolk Street, Strand, London, W.C., send us their monthly house organ for June and July, and also pamphlets relating to the electrification of excavating shovels, electric arc welding, electrical apparatus for the metallurgical and chemical industries, the electrical precipitation and recovery of dust, smoke, and fume from gases, automatic railway substations, and the electrification of steam railways.

SIR W. G. ARMSTRONG, WHITWORTH & Co., LTD., announce that they have secured the services of R. P. Tod, M.I.Mech.E., M.I.Met., in connexion with their hydro-electric work. Many of our readers will have met Mr. Tod on visits which they have paid to the British Aluminium Co.'s works at Kinlochleven, where he has been since 1907, and where originally he was in charge of the erection of the pipe-lines and turbines of 30,000 h.p. Mr. Tod has, until recently, been manager-in-chief over the whole of the British Aluminium Co.'s undertaking at Kinlochleven.

SOZOL, LIMITED, of 20, Copthall Avenue, London, E.C. 2, send us samples of their anti-rust and anti-corrosion preparations. These liquids form a film on the metal surface in the nature of an adsorption or molecular effect, and the film is not easily removed mechanically, though it is amenable to soap and boiling water. Sozol ought to be of great value to the engineer in charge of mine plants and stores. Elsewhere in this issue we quote the covering patent, granted to Professor Edwin Edser and Otto Reynard. The proprietary company is controlled by Minerals Separation, Ltd., and the sale agents for the United Kingdom are F. Simmonds & Co., 1 to 3, Regent Street, London, S.W. 1.

HILL & Co., ENGINEERS, LTD., of 7, Hobart Place, London, S.W. 1, showed the Sauerman cableway excavator at the recent Building Trades Exhibition at Olympia. This excavator consists primarily of a scraper bucket attached by flexible chain connexions to a patented type of carrier running on an inclined track cable, this cable being supported at the upper end by tension blocks to a well-guyed mast and anchored at the lower end to a movable A-frame or bridle anchorage. A load cable is attached to the front of the bucket and carrier. This cable performs the operation of loading the bucket and conveying it along the track cable to the dumping point. A tension cable is provided for operating the tension or fall blocks at the top of the mast or tower. This cable and the blocks tighten and slacken the track cable. Both the load and tension cables lead from guide blocks at the top of a mast or tower down to a double drum friction hoist, usually located at ground level. The machine is designed for excavating and conveying sand, iron ore, or gravel, and will dig, elevate, convey, and dump the material in a continuous operation under the control of one man

METAL MARKETS

COPPER.—The standard copper market in London exhibited a fairly steady tendency during the first half of last month, but during the latter half weakness set in and values receded. The settlement of the coal dispute, however, caused a better feeling at the end of the month. The easier tone was in sympathy with weaker American advices, holders in the United States showing greater willingness to cut prices than had been the case for some time. A simultaneous fall in the value of the pound sterling in New York failed to give London quotations any support. Sentiment during the month was inclined to be somewhat variable, according to whether the coal news was favourable or unfavourable in regard to a speedy termination of the stoppage. The demand from British consumers has been poor, and is certainly unlikely to revive until coal supplies are again plentiful. Inquiry from the Continent at the beginning of the month was moderate, but had a slackening tendency later, although Germany continued to feature as a buyer on a fair scale. It is interesting to note that Germany was the largest single importer of copper from America during April, taking 7,000 tons, while France took 4,500 tons and the United Kingdom 3,600 tons. Italy appears to have purchased more rough copper for sulphate-making than she actually needed, and it is quite possible that she may find herself compelled to make resales. Advices from the United States indicate that production there was only 46,000,000 lb. in May against 90,000,000 lb. in April, and it is estimated that by July the figure should not be more than 35,000,000 lb. On this basis it is expected that the second half of the current year should witness a considerable reduction in the existing large stocks of electrolytic copper in the United States, as consumption should then far exceed the restricted production.

Average price of cash standard copper: June, 1921, £71 18s. 2d.; May, 1921, £73 5s. 10d.; June, 1920, £88; May, 1920, £96 18s. 1d.

DAILY LONDON METAL PRICES: OFFICIAL CLOSING

Copper, Lead, Zinc, and Tin per Long Ton.

COPPER

	Standard Cash	Standard 3 mos.	Electrolytic	Wire Bars	Best Selected
June	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.
9	73 10 0 to 73 12 6	73 12 6 to 73 15 0	77 0 0 to 79 0 0	77 0 0 to 79 0 0	73 0 0 to 75 0 0
10	73 0 0 to 73 2 6	73 5 0 to 73 7 6	77 0 0 to 79 0 0	77 0 0 to 79 0 0	73 5 0 to 75 5 0
13	73 2 6 to 73 5 0	73 7 6 to 73 10 0	77 0 0 to 79 0 0	77 0 0 to 79 0 0	73 5 0 to 75 5 0
14	73 7 6 to 73 10 0	73 7 6 to 73 10 0	77 0 0 to 79 0 0	77 0 0 to 79 0 0	73 10 0 to 75 10 0
15	73 0 0 to 73 2 6	73 2 6 to 73 5 0	77 0 0 to 79 0 0	77 0 0 to 79 0 0	73 10 0 to 75 10 0
16	72 12 6 to 72 15 0	72 17 6 to 73 0 0	77 0 0 to 79 0 0	77 0 0 to 79 0 0	73 10 0 to 75 10 0
17	71 17 6 to 72 0 0	72 2 6 to 72 5 0	77 0 0 to 78 0 0	77 0 0 to 78 0 0	72 0 0 to 74 0 0
20	71 0 0 to 71 2 6	71 2 6 to 71 5 0	76 0 0 to 78 0 0	76 0 0 to 78 0 0	72 0 0 to 74 0 0
21	70 7 6 to 70 10 0	70 10 0 to 70 12 6	75 0 0 to 77 0 0	75 0 0 to 77 0 0	70 10 0 to 72 10 0
22	70 5 0 to 70 7 6	70 5 0 to 70 7 6	74 0 0 to 76 0 0	74 0 0 to 76 0 0	70 10 0 to 72 10 0
23	69 12 6 to 69 15 0	69 17 6 to 70 0 0	74 0 0 to 76 0 0	74 0 0 to 76 0 0	70 10 0 to 72 10 0
24	69 7 6 to 69 10 0	69 12 6 to 69 15 0	73 10 0 to 75 10 0	73 10 0 to 75 10 0	69 15 0 to 71 15 0
27	70 12 6 to 70 15 0	70 17 6 to 71 0 0	74 0 0 to 76 0 0	74 0 0 to 76 0 0	69 15 0 to 71 15 0
28	70 5 0 to 70 7 6	70 12 6 to 70 15 0	74 0 0 to 76 0 0	74 0 0 to 76 0 0	70 10 0 to 72 10 0
29	70 5 0 to 70 7 6	70 10 0 to 70 15 0	74 0 0 to 76 0 0	74 0 0 to 76 0 0	70 10 0 to 72 10 0
30	71 2 6 to 71 7 6	71 10 0 to 71 12 6	75 0 0 to 77 0 0	75 0 0 to 77 0 0	70 10 0 to 72 10 0
July					
1	71 17 6 to 72 0 0	72 2 6 to 72 5 0	75 10 0 to 77 10 0	75 10 0 to 77 10 0	72 10 0 to 74 10 0
4	71 17 6 to 72 0 0	72 2 6 to 72 5 0	75 10 0 to 77 10 0	75 10 0 to 77 10 0	72 10 0 to 74 10 0
5	72 5 0 to 72 7 6	72 5 0 to 72 7 6	75 10 0 to 77 10 0	75 10 0 to 77 10 0	72 10 0 to 74 10 0
6	72 0 0 to 72 2 6	72 2 6 to 72 5 0	75 10 0 to 77 10 0	75 10 0 to 77 10 0	72 10 0 to 74 10 0
7	72 7 6 to 72 10 0	72 7 6 to 72 10 0	75 10 0 to 77 10 0	75 10 0 to 77 10 0	72 10 0 to 74 10 0
8	72 7 6 to 72 10 0	72 7 6 to 72 10 0	75 10 0 to 77 10 0	75 10 0 to 77 10 0	73 0 0 to 75 0 0

TIN.—Despite temporary rallies, the standard tin market during June was characterized by a weak tendency, and values closed the month considerably below the opening quotations. The prolongation of the coal stoppage, combined with general industrial depression and unfavourable reports from the American market, made this downward movement almost inevitable. Professional dealings on 'Change constituted the bulk of the business transacted, in the absence of any appreciable consuming demand. The tinplate works have been taking practically nothing, but it is believed that their stocks are low, and that they will find it necessary to make fair purchases when operations are resumed on a larger scale. In the meantime, the outlook is obscure and it is difficult to take a really favourable view of the market. In America business is dull, and although dealers there have been making purchases both in the Straits and China, the motive appears to have been the acquisition of stocks rather than the satisfaction of demand. The rise in the dollar might have been expected to bring in some American buying on the London market, but this did not materialize. In the East holders have been more willing to sell, and there is a suspicion that producers are finding it difficult to dispose of their current production, with the result that the large stocks held there by the various interests are still being added to. While the tin market is a notoriously erratic one, it seems rather unlikely that it will assume a very firm appearance while general conditions are so unfavourable, although, of course, the cessation of the coal stoppage may cause fresh optimism in the near future.

Average price of cash standard tin: June, 1921, £167 12s. 10d.; May, 1921, £177 10s. 8d.; June, 1920, £250 18s. 6d.; May, 1920, £295 3s. 7d.

LEAD.—The London lead market kept very steady during June, although business at times was quiet. Spain continued to be practically the only source of supplies for the London market, and in this connexion it is interesting to note that some Spanish mines at least are able to sell at a profit at current prices. The other producing countries, however, have been sending very little. Nothing can be expected from Australia at the present time, and there is little chance that Burma will have any metal to spare. Germany may, of course, find it possible to ship some metal in the near future, but at the present time—whatever the reason—is adopting a waiting policy. In Mexico the Government seems to anticipate a revival of activity as soon as conditions are more favourable, and large quantities of ore are being dispatched to the smelter of the American Smelting and Refining Co. at Chihuahua in readiness for the resumption of operations, whenever that may be. The price in the United States has been easy of late, having fallen from 5 cents to 4·50 cents per lb., which increases the possibility of offerings in London from that quarter, although the recent rise in the dollar militates against such sales. In the meantime, arrivals from the chief exporting country, Spain, continue somewhat irregular owing to bunkering difficulties. Consumers here have generally bought for prompt delivery in furtherance of their policy of only taking metal for their immediate requirements, and their doing so has probably helped to keep the market firm by creating a premium for prompt metal. In the United States there appears to be some reluctance on the part of producers to curtail mining operations because of the good price obtainable for the silver recovered.

Average price of soft pig lead: June, 1921, £22 9s. 1d.; May, 1921, £23 7s. 3d.; June, 1920, £35 1s. 4d.; May, 1920, £39 3s. 2d.

SPELTER.—The London spelter market fluctuated during the past month, but values on the whole were fairly steady. Despite the poor industrial outlook, there was an absence of selling pressure. Consuming demand, of course, was restricted, owing to the poor state of the galvanizing trade and the coal stoppage, but, nevertheless, there was a steady though small inquiry. The attitude of the Continental producers appeared to be quite firm. Germany offered very little, being hampered by the reparations legislation and by the troubles in the zinc-producing province of Silesia, while Belgium and Norway were not disposed to make sales

PRICES ON THE LONDON METAL EXCHANGE.
Silver per Standard Ounce; Gold per Fine Ounce.

Lead: Soft Foreign	Lead: English	Zinc (Spelter)	Standard Tin: Cash	Standard Tin: 3 mos.	Silver: Cash	Silver: Forward	Gold	
£ s. d. £ s. d.	£ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	d.	d.	s. d.	June
23 7 6 to 23 0 0	24 10 0	26 15 0 to 27 15 0	168 15 0 to 169 0 0	170 15 0 to 171 0 0	35	34¾	110 4	9
23 2 6 to 22 12 6	24 5 0	27 0 0 to 27 17 6	165 15 0 to 166 0 0	167 5 0 to 167 10 0	35⅛	35¼	111 0	10
22 10 0 to 22 0 0	23 15 0	27 5 0 to 28 0 0	137 0 0 to 167 5 0	169 5 0 to 169 10 0	35¾	35½	110 5	13
22 2 6 to 21 17 6	23 5 0	26 15 0 to 27 10 0	167 10 0 to 167 15 0	169 10 0 to 169 15 0	35⅝	35½	110 0	14
22 5 0 to 22 0 0	23 5 0	26 15 0 to 27 12 6	168 15 0 to 169 0 0	171 10 0 to 171 15 0	35	35	109 2	15
22 5 0 to 22 0 0	23 5 0	26 15 0 to 27 10 0	170 5 0 to 170 10 0	172 15 0 to 173 0 0	34⅝	34⅝	108 7	16
22 2 6 to 22 0 0	23 5 0	26 15 0 to 27 7 6	167 10 0 to 167 15 0	170 0 0 to 170 5 0	34⅞	34⅞	108 2	17
22 2 6 to 22 0 0	23 5 0	26 10 0 to 27 5 0	166 10 0 to 167 0 0	169 0 0 to 169 10 0	35¼	35⅝	108 1	20
21 15 0 to 21 12 6	23 0 0	26 10 0 to 27 0 0	164 10 0 to 164 15 0	167 5 0 to 167 10 0	35⅜	35⅝	109 1	21
21 17 6 to 21 15 0	23 0 0	26 10 0 to 27 0 0	164 0 0 to 164 5 0	166 15 0 to 167 0 0	35⅛	35⅜	109 7	22
22 5 0 to 22 2 6	23 10 0	26 10 0 to 27 2 6	165 10 0 to 165 15 0	167 15 0 to 168 0 0	35⅛	35⅛	109 9	23
22 10 0 to 22 7 6	24 0 0	26 12 6 to 27 5 0	165 15 0 to 166 0 0	167 15 0 to 168 0 0	35	35	110 5	24
23 2 6 to 23 0 0	24 10 0	27 15 0 to 27 15 0	166 12 6 to 166 17 6	168 17 6 to 169 0 0	35⅛	35	109 6	27
23 10 0 to 23 5 0	24 15 0	26 15 0 to 27 2 6	166 10 0 to 166 15 0	169 0 0 to 169 5 0	35⅛	35	109 5	28
23 7 6 to 23 0 0	24 10 0	26 15 0 to 27 5 0	166 0 0 to 166 5 0	168 5 0 to 168 10 0	35⅝	35½	109 3	29
23 7 6 to 23 2 6	24 10 0	27 5 0 to 27 12 6	167 0 0 to 167 5 0	169 5 0 to 169 10 0	35⅜	35⅜	110 0	30
								July
23 5 0 to 23 2 6	24 10 0	27 2 6 to 27 12 6	169 0 0 to 169 5 0	171 0 0 to 171 5 0	35¼	35¼	110 1	1
23 0 0 to 23 0 0	24 10 0	26 10 0 to 27 5 0	170 15 0 to 171 0 0	172 15 0 to 173 0 0	35⅞	35¾	110 3	4
22 5 0 to 23 5 0	24 10 0	26 7 6 to 27 2 6	172 5 0 to 172 10 0	174 5 0 to 174 10 0	36⅞	36½	110 1	5
23 5 0 to 23 5 0	24 10 0	26 17 6 to 27 7 6	169 10 0 to 169 15 0	171 10 0 to 171 15 0	36¼	36	110 4	6
23 7 6 to 23 5 0	24 10 0	26 17 6 to 27 7 6	168 10 0 to 168 15 0	170 10 0 to 170 15 0	36¼	36	110 9	7
23 2 6 to 23 0 0	24 10 0	26 17 6 to 27 7 6	148 7 6 to 168 12 6	170 7 6 to 170 10 0	36⅝	36¼	110 10	8

at the expense of prices. Production in Belgium during May was 4,360 tons, or 40 tons more than in April. In America the market has been quiet and easy, with consuming demand poor, although both India and Japan have made purchases there. The United States output in May has been estimated at 18,000 tons, or about 1,500 tons more than in April, and 2,300 more than in March. Deliveries during May amounted to 14,000 tons, so stocks were increased during the month by some 4,000 tons. It would appear that the current yearly production of America is the lowest since 1904.

Average price of spelter: June, 1921, £27 2s. 2d. May, 1921, £27 6s. 7d.; June, 1920, £40 2s. 11d.; May, 1920, £46 0s. 9d.

ZINC DUST.—The market is quiet and moderately steady. Australian high-grade zinc dust is quoted at about £55, and English 92 to 94% is priced at £53, but other makes are obtainable around £52.

ANTIMONY.—Ordinary brands of English regulus are still quoted at £37 to £40, special brands at £38 5s. to £42, and 98 to 99% at £29 to £32. Foreign is quoted at about £24.

ARSENIC.—Business is dull, and the quotation nominal at £46 to £48 per ton, delivered London or Liverpool.

BISMUTH.—The price has kept very steady at 7s. 6d. per lb.

CADMIUM.—Sellers have made no alteration in the quotation, which continues at 6s. to 6s. 3d. per lb.

ALUMINIUM.—British producers continue to quote £150 per ton for both home and export business, but foreign metal is obtainable at considerably below this figure.

NICKEL.—The price was advanced £5 during the month to £190 for both home and export.

COBALT METAL.—The quotation remains at 15s. to 16s. per lb.

COBALT OXIDE.—There has been no recent change in prices, black oxide being quoted at 12s. and grey at 13s. 6d. per lb.

PLATINUM AND PALLADIUM.—Prices have kept steady, raw platinum being obtainable at about £17 and raw palladium at £15, while manufactured metal is quoted at £20 per oz in both cases.

QUICKSILVER.—Values have had an easier tendency, and the present quotation is about £11 per bottle.

SELENIUM.—The quotation is unchanged at 10s. 6d. to 13s. per lb.

TELLURIUM.—The price continues at 90s. to 95s. per lb.

SULPHATE OF COPPER.—£30 per ton is quoted for both home and export business.

MANGANESE ORE.—The market has had a slightly easier tone, and Indian grades are quoted at 1s. 2½d. per unit c.i.f. U.K

TUNGSTEN ORE.—This market has continued dull and variable. We call the price of 65% WO_3 about 10s. 6d. to 12s. per unit c.i.f.

MOLYBDENITE.—The price is somewhat easier at 42s. 6d. to 50s. per unit c.i.f. nominal.

CHROME ORES.—Values have tended to weaken, and Indian and African grades are now quoted at £4 10s. to £5 per ton c.i.f.

SILVER.—The tendency was upwards during the month. Spot bars opened at 33½d. on the 1st, rose to 35⅝d. on the 11th, weakened to 34⅝d. on the 16th, recovered to 35⅝d. on the 20th, and closed on the 30th at 35⅜d.

GRAPHITE.—Sellers continue to quote Madagascar 80% to 90% at £20 to £25 per ton c.i.f.

IRON AND STEEL.—The prolongation of the coal strike continued adversely to affect the iron and steel trades. Stocks of pig iron have diminished, and premiums have been asked for July delivery where obtainable. With the strike over, pig iron producers will only restart their furnaces again if the settlement includes terms which will allow of cheaper fuel. In the meantime, Continental material has been coming over at cheap prices, Belgian foundry iron being offered at £5 c.i.f. U.K., against the official minimum home trade price for No. 3 Cleveland of £6. The depression in the finished iron and steel trades has continued, and though makers will now be able to resume operations provided fuel and raw material are cheaper, few have sufficient orders for one week's rolling. In the meantime, orders have been lost to Germany, Belgium, and the United States.

STATISTICS

Production of Gold in the Transvaal.

	Rand	Else-where	Total	Price of
	Oz.	Oz.	Oz.	Gold per oz.
				s. d.
May, 1920	681,551	17,490	699,041	105 0
June	699,199	16,758	715,957	102 6
July	718,521	17,578	736,099	105 0
August	683,604	18,479	702,083	112 6
September	665,486	16,687	682,173	115 0
October	645,819	16,653	662,472	117 6
November	618,525	15,212	633,737	117 6
December	617,549	14,666	632,215	115 0
Total, 1920	7,949,038	204,587	8,153,625	
January, 1921 ...	637,425	14,168	651,593	105 0
February	543,767	14,370	588,137	103 9
March	656,572	14,551	671,123	103 9
April	665,309	16,073	681,382	103 9
May	671,750	16,026	687,776	103 9

Natives Employed in the Transvaal Mines.

	Gold mines	Coal mines	Diamond mines	Total
May 31, 1920	184,722	12,897	4,793	202,412
June 30	179,827	13,036	4,596	197,459
July 31	174,187	13,005	4,521	191,713
August 31	169,263	13,535	4,244	187,042
September 30	163,132	13,716	4,323	181,171
October 31	159,426	13,858	4,214	177,498
November 30	158,773	14,245	3,504	176,522
December 31	159,671	14,263	3,340	177,274
January 31, 1921 ...	165,287	14,541	3,319	183,147
February 28	171,518	14,697	1,612	187,827
March 31	174,364	14,906	1,364	190,634
April 30	172,826	14,908	1,316	189,050
May 31	170,595	14,510	1,302	186,407

Cost and Profit on the Rand.

Compiled from official statistics published by the Transvaal Chamber of Mines.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
May, 1920 ...	2,117,725	31 9	25 11	5 10	618,147
June	2,146,890	31 10	25 2	6 8	692,510
July	2,194,050	33 6	24 6	9 0	985,058
August	2,057,560	36 11	25 0	11 11	1,226,906
September ...	1,950,410	38 11	25 6	13 5	1,276,369
October	1,871,140	39 9	26 1	13 8	1,278,385
November ...	1,799,710	40 2	26 2	13 1	1,255,749
December ...	1,797,970	39 11	26 8	13 3	1,193,672
January, 1921	1,895,235	35 0	26 3	8 9	829,436
February	1,575,320	35 6	28 6	7 0	550,974
March	1,958,730	34 5	26 1	8 4	813,636
April	1,991,815	34 5	25 10	8 7	854,533

Production of Gold in Rhodesia.

	1919	1920	1921
	£	oz.	oz.
January	211,917	43,428	46,956
February	220,885	44,237	40,816
March	225,808	45,779	31,995
April	213,160	47,000	47,858
May............	218,057	46,266	48,744
June	214,215	45,054	—
July	214,919	46,208	—
August	207,339	48,740	—
September	223,719	45,471	—
October	204,184	47,343	—
November	186,462	46,782	—
December	158,835	46,190	—
Total ...	2,499,498	552,498	222,369

Transvaal Gold Outputs.

	April		May	
	Treated Tons	Yield Oz.	Treated Tons	Yield Oz.
Aurora West	10,800	£14,596†	10,850	£15,378†
Brakpan	55,000	22,476	54,500	22,705
City Deep	80,000	£182,518*	86,000	37,251
Cons. Langlaagte	43,000	£65,123†	39,000	£65,209†
Cons. Main Reef	48,000	£85,563*	48,000	17,684
Crown Mines	192,000	£280,545*	188,000	[illegible]
D'rb'nRoodepoortDeep	26,550	£45,663*	27,500	9,638
East Rand P.M.	135,000	£186,518*	130,000	35,858
Ferreira Deep	31,800	£55,717*	33,100	10,967
Geduld........	44,000	15,150	46,000	15,670
Geldenhuis Deep	49,765	£67,418*	48,637	13,240
Glynn's Lydenburg ...	3,533	£6,686‡	3,370	£6,829§
Goch	17,000	£19,937†	16,300	£20,162†
Government G.M. Areas	136,000	£287,860†	134,000	£280,030†
Kleinfontein	47,100	13,114	47,700	13,345
Knight Central........	28,800	£37,150*	27,500	7,167
Langlaagte Estate	38,400	£62,270†	38,500	£63,448†
Luipaard's Vlei	20,380	£21,946†	20,770	£24,112†
Meyer & Charlton	14,000	£41,467†	13,700	£42,166†
Modderfontein	96,000	£224,885*	88,000	43,689
Modderfontein B	58,000	£158,368*	58,000	32,938
Modderfontein Deep ..	42,600	22,916	41,300	23,233
Modderfontein East....	25,700	£51,285*	24,000	10,353
New Unified	11,300	£14,062†	11,000	£13,202†
Nourse	46,000	£73,959*	42,200	13,909
Primrose	21,500	£23,759†	20,900	£23,307†
Randfontein Central ..	128,500	£183,309†	121,000	£183,779†
Robinson.............	39,000	£40,446*	38,500	8,035
Robinson Deep	61,300	13,114	59,000	18,147
Roodepoort United ...	23,800	£23,189†	22,400	£23,[illegible]†
Rose Deep	54,500	£68,043*	52,000	13,705
Simmer & Jack	60,600	14,469	60,000	14,617
Springs	42,000	18,631	43,900	19,596
Sub Nigel	9,900	6,043	9,000	5,914
Transvaal G.M. Estates.	15,030	£25,583‡	15,620	£24,312§
Van Ryn	31,520	£49,063†	32,500	£48,437†
Van Ryn Deep	50,400	£140,608†	49,000	£136,246†
Village Deep	48,600	£76,730*	46,000	15,141
West Rand Consolidated	32,220	£47,947†	33,100	£48,411†
Witw'tersr'nd (Knights)	36,000	£49,820†	35,300	£48,442†
Witwatersrand Deep ..	35,000	14,491	35,200	9,568
Wolhuter............	31,700	£41,704*	31,400	7,970

* Gold at £5 3s. 3d. per oz. † £5 3s. 9d. per oz. ‡ £5 2s. 9d. per oz. § £5 1s. 3d. per oz.

Rhodesian Gold Outputs.

	April		May	
	Tons	Oz.	Tons	Oz.
Cam & Motor	11,100	£11,500†	11,200	£12,978†
Falcon	15,293	3,086	15,637	3,144*
Gaika	3,503	1,254	3,324	1,281
Globe & Phœnix	6,083	4,744	6,364	5,069
Jumbo	1,399	464	1,350	470
London & Rhodesian ..	—	£2,592	—	£3,422
Lonely Reef	5,320	5,299	5,440	5,396
Planet-Arcturus	5,450	2,592	5,820	2,942
Rezende	5,700	2,601	5,800	2,630
Rhodesia G.M. & I. ..	259	234	245	210
Shamva	52,350	£39,825‡	55,500	£42,582‡
Transvaal & Rhodesian	1,790	£5,184†	1,600	£5,307†

* Also 270 tons copper. † At par. ‡ Gold at £5 5s. per oz. ‖ Also 272 tons copper.

West African Gold Outputs.

	April		May	
	Treated	Value	Treated	Value
	Tons	Oz.	Tons	Oz.
Abbontiakoon	6,604	£10,663*	6,864	£10,867*
Abosso	5,012	1,952	5,825	2,252
Akoko	—	—	—	—
Ashanti Goldfields	5,759	5,325	6,727	7,839
Obbuassi	760	£2,838†	1,018	£3,265†
Prestea Block A.......	5,445	£9,993*	7,312	£12,437*
Taquah	2,200	1,363	2,600	1,664

* At par. † Including premium.

West Australian Gold Statistics.—Par Values.

	Reported for Export Oz.	Delivered to Mint Oz.	Total Oz.	Total Value £
September, 1920 ..	141	54,940	55,081	233,963
October	174	53,801	53,975	229,275
November	128	54,729	54,857	233,017
December	321	53,595	53,916	229,057
January, 1921	523	50,934	51,457	218,574
February	684	26,872	27,556	117,050
March............	10	47,875	47,885	202,401
April	607	46,602	47,209	200,635
May	474	47,638	51,503	217,495
June...	153	28,194	28,347	120,410

Australian Gold Outputs.

	West Australia	Victoria	Queensland	New South Wales
1921	oz.	oz.	oz.	£
January .	51,458	4,587	4,582	20,463
February .	27,557	10,940	9,046	21,575
March ...	47,886	12,383	6,690	24,344
April	47,273	—	—	34,101
May		—	—	15,356
June.....		—	—	—
July		—	—	—
August...	—	—	—	—
September	—	—	—	—
October .	—	—	—	—
November	—	—	—	—
December	—	—		—
Total ..	174,174	27,910	20,318	115,929

Australasian Gold Outputs.

	April		May	
	Tons	Value £	Tons	Value £
Associated G.M. (W.A.)	5,977	6,890‖	6,023	7,285‖
Blackwater (N.Z.)	2,888	5,110*	2,744	5,455*
Bullfinch (W.A.)	—	—		—
Gold'n Horseshoe (W.A)	9,024	4,747‡	4,032	2,454
Grt Boulder Pro. (W.A.)	9,033	27,099‖	4,156	12,883‖
Ivanhoe (W.A.)	12,217	5,773‡	4,483	1,531‡
Kalgurli (W.A.)	—	—	4,958	11,250‖
Lake View & Star (W.A.)	6,656	14,717†‖	4,012	10,274†‖
Menzies Con. (W.A.) ..	1,760	2,928*	—	—
Mount Boppy (N.S.W.)	3,696	1,045‡	4,874	835‡
Oroya Links (W.A.) ...	1,442	9,235†	1,548	7,418†‖
Progress (N.Z.)........	—	—	—	—
Sons of Gwalia (W.A.) .	—	—	—	—
South Kalgurli (W.A.) .	7,081	12,402‖	—	—
Waihi (N.Z.)..........	10,967	2,997‡ 31,134§	11,959	3,511‡ 25,738§
„ Grand Junc'n (N.Z.)	5,260	1,737‡ 5,947§	6,020	1,790‡ 6,089§
Yuanmi (W.A.)	1,512	5,407*	1,632	5,511*

* Including premium ; † Including royalties ; ‡ Oz. gold ; § Oz. silver ; ‖ At par.

Miscellaneous Gold and Silver Outputs.

	April		May	
	Tons	Value £	Tons	Value £
Brit. Plat. & Gold (C'lbia)	—	326§	—	282§
El Oro (Mexico)	31,500	206,000†	34,500	207,000†
Esperanza (Mexico)	—	2,318†‡	—	2,188†‡
Frentino & Bolivia (C'lbia)	2,270	7,997	2,340	8,777
Mexico El Oro (Mexico)..	11,200	182,780†	11,500	184,780†
Mining Corp. of Canada .	—	—	—	—
Oriental Cons. (Korea) ...	16,365	97,958†	—	94,000†
Ouro Preto (Brazil)	7,100	2,222‖	6,700	2,410‖
Plym'th Cons. (Calif'rnia	9,600	10,663	8,600	8,900
St. John del Rey (Brazil).	—	40,000	—	38,000
Santa Gertrudis (Mexico)	35,053	13,421‡	37,258	10,742‡
Tolima (Colombia)	90**	—	55**	—
Tomboy (Colorado)	16,000	48,500†	19,000	65,000†

* Oz. silver. † U.S. Dollars. ‡ Profit, gold and silver. ‖ Oz. gold. § Oz. platinum and gold. ** Production of silver ore.

Pato (Colombia) : 28 days to June 7, $8,271 from 14,266 cu. yd.; 7 days to June 14, $7,530 from 17,338 cu. yd.; 8 days to June 23, $12,470 from 46,057 cu. yd.

Nechi (Colombia) : 29 days to June 1, $27,315 from 172,972 cu. yd.; 12 days to June 13, $18,035 from 91,620 cu. yd.

Indian Gold Outputs.

	April.		May.	
	Tons Treated	Fine Ounces	Tons Treated	Fine Ounces
Balaghat	3,200	2,328	3,300	2,609
Champion Reef	11,610	4,492	12,215	4,561
Mysore...............	15,690	11,027	16,818	10,776
North Anantapur	700	901	700	913
Nundydroog	8,456	5,189	8,639	5,315
Ooregum	12,500	8,426	12,900	8,482

Production of Gold in India.

	1917	1918	1919	1920	1921
	Oz.	Oz.	Oz.	Oz.	Oz.
January	44,718	41,420	38,184	39,073	34,028
February ...	42,566	40,787	36,384	38,872	32,529
March	44,617	41,719	38,317	38,760	32,576
April	43,726	41,504	38,248	37,307	32,363
May........	42,901	40,889	38,608	38,191	32,656
June	42,924	41,264	38,359	37,864	—
July	42,273	40,229	38,549	37,129	—
August	42,591	40,496	37,850	37,375	—
September ..	43,207	40,088	36,813	35,497	—
October	43,041	39,472	37,138	35,023	—
November ..	42,915	36,984	39,628	34,522	—
December ..	44,883	40,149	42,643	34,919	—
Total ..	520,362	485,236	461,171	444,532	164,162

Base Metal Outputs.

		April	May
Arizona Copper	Short tons copper ..	1,000	—
British Broken Hill ...	Tons lead conc. ...	—	—
	Tons zinc conc.	—	—
	Tons carbonate ore	—	—
Broken Hill Prop......	Tons lead conc. ...	—	—
	Tons zinc conc.	—	—
Broken Hill South	Tons lead conc.	2,673	2,897
Burma Corp.	Tons refined lead ..	2,369	2,781
	Oz. refined silver ..	231,934	353,003
Hampden Cloncurry ..	Tons copper	—	—
	Oz. gold	—	—
Mount Lyell	Tons copper	439	435
	Oz. silver	11,073	10,432
	Oz. gold	292	277
Mount Morgan	Tons Copper	—	—
	Oz. gold	—	—
North Broken Hill.....	Tons lead	—	—
	Oz. silver	—	—
Rhodesia Broken Hill	Tons lead	1,812	1,769
Sulphide Corporation ..	Tons lead conc. ...	1,806	1,906
	Tons zinc conc	2,726	3,093
Tanganyika	Tons copper	2,189	2,846
Zinc Corporation	Tons zinc conc......	8,520	9,745
	Tons lead conc. ...	617	811

Imports of Ores, Metals, etc., into United Kingdom.

		April	May
Iron Ore	Tons .	123,583	15,696
Manganese Ore	Tons .	7,694	21,518
Copper and Iron Pyrites	Tons .	14,662	5,170
Copper Ore, Matte, and Prec.	Tons .	7,744	291
Copper Metal	Tons .	11,840	7,609
Tin Concentrate	Tons .	1,953	1,051
Tin Metal......................	Tons .	317	1,205
Lead, Pig and Sheet	Tons .	7,951	10,709
Zinc (Spelter)	Tons .	11,401	2,206
Quicksilver	Lb. .	411,316	7,865
Zinc Oxide.....................	Tons .	328	309
White Lead	Cwt. .	4,770	2,885
Barytes, ground	Cwt. .	21,133	6,987
Phosphate	Tons .	28,210	11,704
Sulphur	Tons .	5	—
Nitrate of Soda................	Cwt. .	114,249	18,994
Petroleum			
Crude	Gallons	7,520,101	9,299,586
Lamp Oil	Gallons	9,992,778	9,034,974
Motor Spirit	Gallons	26,191,585	28,364,422
Lubricating Oil	Gallons	3,374,996	3,750,784
Gas Oil	Gallons	3,067,510	1,494,292
Fuel Oil	Gallons	46,588,689	47,952,217

Outputs of Tin Mining Companies.

In Tons of Concentrate

	March	April	May.
Nigeria:	Tons	Tons	Tons
Associated Nigerian	—	—	—
Bisichi	22	27	28
Bongwelli	—	—	—
Champion Nigeria	—	—	—
Dua	¼	—	—
Ex-Lands	25	29	—
Filani	—	2	2
Gold Coast Consolidated ...	3	—	—
Gurum River	13	7	7
Jantar..................	—	—	22†
Jos	16	6	4
Kaduna	—	10	11
Kaduna Prospectors	14	11	8¾
Kano	3	—	—
Lower Bisichi	6½	4½	3
Lucky Chance	—	—	—
Mines	3	—	—
Mongu	53	36	32½
Naraguta	70	45	40
Naraguta Extended	8	8	8
Nigerian Consolidated	29	8	6½
N.N. Bauchi	45	41½	42
Offin River............	—	—	—
Rayfield	28	30	—
Ropp	97	95	97
Rukuba	4½	5	3
South Bukeru	12	20	10
Sybu	⅛	1⅜	1¾
Tin Fields	6	4	—
Yarde Kerri	13	13	11
Federated Malay States:			
Chenderiang..............	81*	—	—
Gopeng	72	77½	83¾
Idris Hydraulic	21	21	19
Ipoh	17½	—	20
Kamunting	122*	—	—
Kinta	30	36	35¾
Lahat	57	51	50½
Malayan Tin	95½	77	83
Pahang	213	230	218
Rambutan	15	15½	16
Sungei Besi	42	34	36
Tekka	30	31	36
Tekka-Taiping............	13½	11	10½
Tronoh	20	22	21
Cornwall:			
East Pool	—	—	—
Geevor	—	—	—
South Crofty	—	—	—
Other Countries:			
Aramayo Francke (Bolivia) .	200	—	—
Berenguela (Bolivia)	31	27	28
Briseis (Tasmania)	8	8	6
Deebook Ronpibon (Siam) ..	30½	28	33
Leeuwpoort (Transvaal)	99*	—	—
Macready (Swaziland)	19*	—	—
Renong (Siam)	21	72	107
Rooiberg Minerals (Transvaal)	50	50	50
Siamese Tin (Siam)	57	76	120
Tongkah Harbour (Siam) ...	37	43	54
Zaaiplaats (Transvaal	—	—	13

* Three months. † Tributers.

Nigerian Tin Production.

In long tons of concentrate of unspecified content.

Note.—These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual output.

	1916	1917	1918	1919	1920	1921
	Tons	Tons	Tons	Tons	Tons	Tons
January	531	667	678	613	547	438
February	528	646	668	623	477	370
March	547	655	707	606	505	445
April	486	555	584	546	467	394
May	536	509	525	483	383	337
June	510	473	492	484	435	—
July	506	479	545	481	484	—
August	498	551	571	616	447	—
September	535	538	529	561	528	—
October	584	578	491	625	628	—
November	679	621	472	536	544	—
December	654	655	518	511	577	—
Total	6,594	6,927	6,771	6,685	6,022	1,984

Production of Tin in Federated Malay States.

Estimated at 70% of Concentrate shipped to Smelters
Long Tons.

	1917	1918	1919	1920	1921
	Tons	Tons	Tons	Tons	Tons
January	3,558	3,030	3,765	4,265	3,298
February	2,755	3,197	2,734	3,014	3,111
March	3,286	2,609	2,819	2,770	2,190
April	3,251	3,308	2,858	2,606	2,692
May.............	3,413	3,332	3,407	2,741	2,884
June	3,489	3,070	2,877	2,940	—
July	3,253	3,373	3,756	2,824	—
August	3,413	3,259	2,956	2,786	—
September	3,154	3,157	3,161	2,734	—
October	3,436	2,870	3,221	2,837	—
November	3,300	3,132	2,972	2,573	—
December........	3,525	3,022	2,469	2,838	—
	39,833	37,370	36,935	34,928	14,175

Stocks of Tin.

Reported by A. Strauss & Co. Long Tons.

	April 30	May 31	June 30
Straits and Australian Spot	1,357	1,430	1,931
Ditto, Landing and in Transit ...	185	585	135
Other Standard, Spot and Landing	5,081	4,457	4,279
Straits, Afloat	775	1,505	1,210
Australian, Afloat	150	150	90
Banca, in Holland	2,867	3,405	3,780
Ditto, Afloat	200	445	485
Billiton, Spot	534	644	528
Billiton, Afloat	—	80	159
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	100	475	585
Total Afloat for United States ...	1,441	2,595	1,225
Stock in America	2,441	2,046	2,546
Total	15,131	17,767	16,953

Shipments, Imports, Supply, and Consumption of Tin.

Reported by A. Strauss & Co. Long tons.

	April	May	June
Shipments from:			
Straits to U.K.	775	1,425	320
Straits to America	925	1,735	600
Straits to Continent	100	507	505
Straits to other places	825	200	350
Australia to U.K.	—	—	25
U.K. to America	295	490	200
Imports of Bolivian Tin into Europe....................	811	353	724
Supply:			
Straits........................	1,800	3,667	1,425
Australian	—	—	25
Billiton	—	150	273
Banca	70	1,180	1,170
Standard	865	394	263
Total	2,735	5,391	3,156
Consumption:			
U.K. Deliveries	1,531	1,000	1,361
Dutch ,, ...	152	398	388
American ,, ...	1,590	1,225	1,590
Straits, Banca & Billiton, Continental Ports, etc.	95	132	631
Total	3,368	2,755	3,970

OUTPUTS REPORTED BY OIL-PRODUCING COMPANIES.

		April	May
Anglo-Egyptian	Tons	12,478	14,173
Anglo-United	Barrels	10,101	10,700
Apex Trinidad	Barrels	39,241	21,000
British Burmah	Barrels	66,200	70,212
Caltex	Barrels	99,290	102,720
Dacia Romana	Tons	288	294
Kern River	Barrels	95,040	94,250
Lobitos	Tons	8,160	8,686
Roumanian Consol	Tons	1,849	1,849
Santa Maria	Tons	1,400	9,600
Steaua Romana	Tons	20,095	19,150
Trinidad Leaseholds	Tons	15,900	13,550
United of Trinidad	Tons	2,813	3,768

QUOTATIONS OF OIL COMPANIES' SHARES.

Denomination of Shares £1 unless otherwise noted.

	June 6, 1921 £	s.	d.	July 6, 1921 £	s.	d.
Anglo-American	4	15	0	4	10	0
Anglo-Egyptian B	1	17	6	1	8	9
Anglo-Persian 1st Pref.	1	2	6	1	2	6
Anglo-United, Wyoming		8	9		5	0
Apex Trinidad	2	5	0	2	0	0
British Borneo (10s.)		16	3		13	9
British Burmah (8s.)	1	0	0	1	0	0
Burmah Oil	6	15	0	6	7	6
Caltex ($1)		6	3		4	3
Dacia Romano	1	0	0	1	0	0
Kern River, Cal. (10s.)	1	1	0		19	6
Lobitos, Peru	4	0	0	4	5	0
Mexican Eagle, Ord. ($5)	6	10	0	5	7	6
,, ,, Pref. ($5)	6	5	0	5	2	6
North Caucasian (10s.)		18	9		17	6
Phœnix, Roumania		10	6		11	9
Roumanian Consolidated		13	6		12	6
Royal Dutch (100 gulden)	47	0	0	42	10	0
Scottish American		10	0		7	0
Shell Transport, Ord.	5	11	3	5	11	3
,, ,, Pref. (£10)	8	10	0	8	10	0
Trinidad Central	4	5	0	3	15	0
Trinidad Leaseholds	2	12	6	2	10	0
United British of Trinidad	1	2	6		18	9
Ural Caspian	1	0	0		17	6
Uroz Oilfields (10s.)		9	0		8	9

DIVIDENDS DECLARED BY MINING COMPANIES.

Date	Company	Par Value of Shares	Amount of Dividend
June 21	Anglo-American of S.A.	£1	5% less tax.
June 23	Apex Mines	10s.	6d.
June 16	British Burmah Petroleum	8s.	12½% less tax.
June 24	Burmah Oil	Or. £1	4s. tax paid.
June 22	California Petroleum	Pr. $100	1¾%
June 26	Clydesdale Collieries	£1	10%
June 15	De Beers Consolidated	Pr.£2 10s	10s. less tax.
June 26	Dundee Coal	£1	7½%
June 22	Exploring Land & Minerals	5s.	5% less tax.
June 18	Frontino & Bolivia	Pr. £1	5% less tax.
June 16	Gopeng Consolidated	£1	9d. less tax.
June 26	Great Boulder Perseverance	£1	5d.*
June 10	Idris Hydraulic Tin	£1	6d. less tax.
June 22	Ivanhoe Gold	£5	1s. 6d. less tax.
June 18	Kramat Pulai	£1	1s. less tax.
July 5	Lobitos Oilfields	£1	15% less tax.
June 21	Mexican Eagle	Or. $500	6% less tax.
June 22	Mexico of El Oro	£1	2s. 6d. tax paid
June 25	Natal Navigation Collieries	£1	2s.
June 11	Nechi (Colombia)	Or. 10s.	5s. less tax.
June 10	Oroville Dredging	£1	9d. less tax.
June 16	Ouro Preto	Or. £1	5% less tax.
June 10	Pato (Colombia)	£1	7s. less tax.
July 2	Poderosa	£1	2s. 6d. less tax.
June 21	Rand Selection	£1	15% less tax.
June 20	Rezende	£1	20% less tax.
June 8	Rhodesia Copper	3s.	12½% less tax.
June 16	Shamva Mines	£1	7½% less tax.

* Fifth distribution on liquidation.

PRICES OF CHEMICALS. July 8.

These quotations are not absolute; they vary according to quantities required and contracts running.

		£	s.	d.
Acetic Acid, 40%	per cwt.	1	3	6
,, 80%	,,	2	7	0
,, Glacial	per ton	68	0	0
Alum	,,	16	0	0
Alumina, Sulphate	,,	14	10	0
Ammonia, Anhydrous	per lb.		2	2
,, 0·880 solution	per ton	30	0	0
,, Carbonate	per lb.			4
,, Chloride, grey	per ton	44	10	0
,, ,, pure	per cwt.	3	15	0
,, Nitrate	per ton	50	0	0
,, Phosphate	,,	75	0	0
,, Sulphate	,,	18	10	0
Antimony, Tartar Emetic	per lb.		2	7
,, Sulphide, Golden	,,		1	5
Arsenic, White	per ton	45	0	0
Barium Carbonate	,,	11	0	0
,, Chlorate	per lb.			11
,, Chloride	per ton	17	0	0
,, Sulphate	,,	8	0	0
Benzol, 90%	per gal.		3	0
Bisulphate of Carbon	per ton	56	0	0
Bleaching Powder, 35% Cl.	,,	18	0	0
,, Liquor, 7%	,,	7	0	0
Borax	,,	34	0	0
Boric Acid Crystals	,,	69	0	0
Calcium Chloride	,,	10	0	0
Carbolic Acid, crude 60%	per gal.		1	7
,, ,, crystallized, 40°	per lb.			6¼
China Clay (at Runcorn)	per ton	4	10	0
Citric Acid	per lb.		2	5
Copper, Sulphate	per ton	30	0	0
Cyanide of Sodium, 100%	per lb.		1	0
Hydrofluoric Acid	,,			7½
Iodine	per oz.		1	0
Iron, Nitrate	per ton	9	0	0
,, Sulphate	,,	4	0	0
Lead, Acetate, white	,,	45	0	0
,, Nitrate	,,	48	0	0
,, Oxide, Litharge	,,	32	0	0
,, White	,,	44	0	0
Lime, Acetate, brown	,,	8	0	0
,, ,, grey 80%	,,	12	0	0
Magnesite, Calcined	,,	21	0	0
Magnesium, Chloride	,,	16	0	0
,, Sulphate	,,	10	0	0
Methylated Spirit 64° Industrial	per gal.		6	0
Nitric Acid, 80° Tw.	per ton	31	0	0
Oxalic Acid	per lb.			9
Phosphoric Acid	per ton	50	0	0
Potassium Bichromate	per lb.			10½
,, Carbonate	per ton	35	0	0
,, Chlorate	per lb.			5
,, Chloride 80%	per ton	20	0	0
,, Hydrate (Caustic) 90%	,,	33	0	0
,, Nitrate	,,	55	0	0
,, Permanganate	per lb.		1	6
,, Prussiate, Yellow	,,		1	3
,, ,, Red	,,		2	3
,, Sulphate, 90%	per ton	20	0	0
Sodium Metal	per lb.		1	4
,, Acetate	per ton	26	0	0
,, Arsenate 45%	,,	44	0	0
,, Bicarbonate	,,	10	10	0
,, Bichromate	per lb.			7½
,, Carbonate (Soda Ash)	per ton	15	0	0
,, ,, (Crystals)	,,	7	0	0
,, Chlorate	per lb.			4
,, Hydrate, 76%	per ton	26	15	0
,, Hyposulphite	,,	17	0	0
,, Nitrate, 96%	,,	18	10	0
,, Phosphate	,,	24	0	0
,, Prussiate	per lb.			7
,, Silicate	per ton	11	15	0
,, Sulphate (Salt-cake)	,,	7	10	0
,, ,, (Glauber's Salts)	,,	6	10	0
,, Sulphide	,,	27	0	0
,, Sulphite	,,	12	10	0
Sulphur, Roll	,,	15	0	0
,, Flowers	,,	15	0	0
Sulphuric Acid, Fuming, 65°	,,	24	0	0
,, ,, free from Arsenic, 144°	,,	6	5	0
Superphosphate of Lime, 30%	,,	8	10	0
Tartaric Acid	per lb.		1	7
Turpentine	per cwt.	4	2	0
Tin Crystals	per lb.		1	5
Titanous Chloride	,,		1	0
Zinc Chloride	per ton	22	10	0
Zinc Sulphate	,,	15	0	0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS:	July 7, 1920 £ s. d.	July 6, 1921 £ s. d.
Rand:		
Brakpan	2 10 0	2 12 6
Central Mining (£8)	8 11 3	6 0 0
City & Suburban (£4)	5 6	3 0
City Deep	2 7 0	2 6 3
Consolidated Gold Fields	1 7 6	18 9
Consolidated Langlaagte	15 6	12 6
Consolidated Main Reef	11 9	9 6
Consolidated Mines Selection (10s.)	1 1 9	13 0
Crown Mines (10s.)	2 6 3	1 15 0
Daggafontein	9 [illegible]	3 6
Durban Roodepoort Deep	3 9	3 9
East Rand Proprietary	6 0	4 3
Ferreira Deep	7 6	7 6
Geduld	1 18 0	2 8 9
Geldenhuis Deep	5 6	7 3
Government Gold Mining Areas	4 2 6	4 1 3
Johannesburg Consolidated	1 8 9	1 3 6
Kleinfontein	6 3	7 3
Knight Central	3 3	4 0
Knights Deep	5 0	15 6
Langlaagte Estate	13 6	13 0
Meyer & Charlton	4 15 0	4 7 6
Modderfontein (£1)	3 10 0	3 7 6
Modderfontein B (5s.)	6 1 3	1 7 6
Modderfontein Deep (5s.)	2 5 0	2 5 0
Modderfontein East	1 2 0	10 0
New State Areas	1 6 3	1 2 6
Nourse	7 9	7 0
Rand Mines (5s.)	2 13 9	2 1 3
Rand Selection Corporation	2 10 0	2 12 6
Randfontein Central	13 9	9 9
Robinson (£5)	8 6	9 6
Robinson Deep A (1s.)	1 0 6	7 6
Rose Deep	16 3	12 3
Simmer & Jack	3 0	2 0
Springs	1 12 6	1 18 6
Sub-Nigel	14 3	12 6
Union Corporation (12s. 6d.)	17 0	15 0
Van Ryn	16 3	12 3
Van Ryn Deep	4 2 6	3 12 6
Village Deep	9 6	7 6
West Springs	13 9	10 0
Witwatersrand (Knight's)	13 9	13 9
Witwatersrand Deep	6 3	6 3
Wolhuter	4 0	3 6
Other Transvaal Gold Mines:		
Glynn's Lydenburg	11 3	6 6
Sheba (5s.)	1 0	1 9
Transvaal Gold Mining Estates	10 0	7 6
Diamonds in South Africa:		
De Beers Deferred (£2 10s.)	20 5 0	10 5 0
Jagersfontein	4 5 0	2 5 0
Premier Deferred (2s. 6d.)	10 15 0	4 0 0
Rhodesia:		
Cam & Motor	10 6	9 6
Chartered British South Africa	17 6	11 9
Falcon	7 3	4 6
Gaika	13 9	9 9
Globe & Phoenix (5s.)	17 6	15 6
Lonely Reef	3 0 0	2 0 0
Rezende	2 15 0	3 10 0
Shamva	1 15 0	1 10 0
Willoughby's (10s.)	5 3	4 6
West Africa:		
Abbontiakoon (10s.)	3 0	2 3
Abosso	12 0	8 3
Ashanti (4s.)	17 0	14 3
Prestea Block A	2 3	1 6
Taquah	10 3	8 6
West Australia:		
Associated Gold Mines	3 0	2 6
Associated Northern Blocks	3 0	2 6
Bullfinch	3 6	1 0
Golden Horse-Shoe (£5)	17 6	10 0
Great Boulder Proprietary (2s.)	7 6	5 0
Great Fingall (10s.)	2 3	1 6
Hampton Properties	12 6	4 9
Ivanhoe (£5)	1 3 9	16 3
Kalgurli	13 9	11 0
Lake View Investment (10s.)	16 0	9 6
Sons of Gwalia	6 0	4 6
South Kalgurli (10s.)	6 0	7 6

GOLD, SILVER, cont.	July 7, 1920 £ s. d.	July 6, 1921 £ s. d.
Others in Australasia:		
Blackwater, New Zealand	8 9	2 6
Consolidated G.F. of New Zealand	3 9	2 6
Mount Boppy, N.S.W. (10s.)	4 3	1 6
Progress, New Zealand	1 9	1 3
Waihi, New Zealand	1 18 9	1 8 9
Waihi Grand Junction, New Z'lnd.	10 0	10 0
America:		
Buena Tierra, Mexico	10 0	2 6
Camp Bird, Colorado	12 6	4 0
El Oro, Mexico	10 9	9 9
Esperanza, Mexico	10 6	1 0 0
Frontino & Bolivia, Colombia	11 3	7 6
Le Roi No. 2 (£5), British Columbia	10 0	2 6
Mexico Mines of El Oro, Mexico	5 5 0	4 5 0
Nechi (Pref. 10s.), Colombia	9 0	7 6
Oroville Dredging, Colombia	1 3 0	1 5 0
Plymouth Consolidated, California	18 9	12 6
St. John del Rey, Brazil	17 9	15 3
Santa Gertrudis, Mexico	1 2 6	5 6
Tomboy, Colorado	7 6	5 0
Russia:		
Lena Goldfields	1 0 0	8 9
Orsk Priority	10 0	5 0
India:		
Balaghat (10s.)	7 6	8 6
Champion Reef (2s. 6d.)	2 6	1 6
Mysore (10s.)	14 3	12 6
North Anantapur	4 0	2 6
Nundydroog (10s.)	11 3	6 0
Ooregum (10s.)	15 0	12 0
COPPER:		
Arizona Copper (5s.), Arizona	2 8 9	1 3 9
Cape Copper (£2), Cape and India	1 2 6	15 0
Esperanza, Spain	5 0	6 3
Hampden Cloncurry, Queensland	13 9	5 0
Mason & Barry, Portugal	1 10 0	1 15 0
Messina (5s.), Transvaal	5 6	4 0
Mount Elliott (£5), Queensland	2 0 0	7 6
Mount Lyell, Tasmania	1 3 9	13 9
Mount Morgan, Queensland	17 6	12 6
Namaqua (£2), Cape Province	1 12 6	15 0
Rio Tinto (£5), Spain	37 10 0	31 0 0
Russo-Asiatic Consd., Russia	10 0	11 0
Sissert, Russia	10 0	7 6
Spassky, Russia	1 0 0	11 3
Tanganyika, Congo and Rhodesia	1 16 3	1 0 0
LEAD-ZINC:		
Broken Hill:		
Amalgamated Zinc	1 7 6	17 6
British Broken Hill	2 0 0	1 1 3
Broken Hill Proprietary	3 2 0	2 2 6
Broken Hill Block 10 (£10)	1 5 0	12 6
Broken Hill North	2 10 0	1 10 0
Broken Hill South	2 10 0	1 8 9
Sulphide Corporation (15s.)	16 9	12 6
Zinc Corporation (10s.)	19 0	8 9
Asia:		
Burma Corporation (10 rupees)	9 15 0	7 6†
Russian Mining	10 0	7 0
Rhodesia:		
Rhodesia Broken Hill (5s.)	10 6	7 0
TIN:		
Aramayo Francke, Bolivia	3 10 0	2 5 0
Bisichi (10s.), Nigeria	12 0	6 6
Briseis, Tasmania	4 3	2 6
Dolcoath, Cornwall	2 9	9
East Pool (5s.), Cornwall	9 0	3 3
Ex-Lands Nigeria (2s.), Nigeria	3 3	1 6
Geevor (10s.), Cornwall	12 6	3 9
Gopeng, Malay	1 17 6	1 12 6
Ipoh Dredging, Malay	16 3	11 3
Kamunting, Malay	2 10 0	1 5 0
Kinta, Malay	2 7 6	1 10 0
Malayan Tin Dredging, Malay	1 18 9	1 7 6
Mongu (10s.), Nigeria	17 6	12 6
Naraguta, Nigeria	10 0	16 3
N. N. Bauchi, Nigeria (10s.)	6 0	2 3
Pahang Consolidated (5s.), Malay	11 0	6 3
Rayfield, Nigeria	9 0	4 0
Renong Dredging, Siam	2 0 0	1 7 6
Ropp (4s.), Nigeria	9 3	6 6
Siamese Tin, Siam	3 5 0	1 12 6
South Crofty (5s.), Cornwall	10 6	4 6
Tehidy Minerals, Cornwall	16 3	7 6
Tekka, Malay	1 1 3	17 6
Tekka-Taiping, Malay	1 6 3	1 1 3
Tronoh, Malay	2 0 0	1 5 0

* New Shares. † 10-rupee shares of Indian Co.

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also notices of new books and pamphlets, lists of patents on mining and metallurgical subjects, and abstracts of the yearly reports of mining companies.

RECOVERY OF ZINC FROM LEAD SLAGS

The *Proceedings* of the Australasian Institute of Mining and Metallurgy, No. 38, 1920, contains a paper by Guy Courtney on the recovery of zinc from lead blast-furnace slags, giving a description of some of the work carried out by the Sulphide Corporation at Cockle Creek. Early in the life of the works it was realized by the metallurgical staff that a very wide field for investigation lay before them. At the head of these was the late F. H Evans, and it was due to his work and suggestions that the question has grown from a mere hypothesis to a commercial undertaking, in so far as these works are concerned. In 1908 a patent was filed by Mr. Evans in conjunction with P. A. M'Kay, which had for its object the expulsion of zinc from lead blast-furnace slags, the operation being carried out either in a blast-furnace or reverberatory furnace supplied with tuyeres. A converter was also proposed, the reduction of the zinc being accomplished by blowing in carbonaceous material in a finely divided condition, or carburetted gas through the molten slag. One of the earliest attempts made at Cockle Creek to drive the zinc from the slag was some fourteen years ago. Compressed air was blown in under the surface of some molten slag. The resultant ebullition drove off large volumes of fume, but, owing to the chilling effect of the cold air, the test could only be maintained for a few minutes. A little later this method was again tried, with certain modifications. An iron pipe was lined with firebrick, leaving an opening 15 in. in diameter and 4 ft. deep. Four inches from the bottom three tuyeres were fitted, equally spaced round the circumference. Attached to the tuyeres were three reservoirs for powdered coal. In starting, the air and coal dust were turned on and hot slag poured in to a depth of about 12 in. above the tuyeres. The agitation, brought about through the blast of air and the combustion of the coal, drove off dense volumes of fume. This continued without abatement for about 45 minutes, which was as long as the supply of fuel lasted. Without proper means of handling the powdered coal, it became a difficult matter to ensure a constant stream being blown in with the air, as at this period little was known of the methods and appliances now in use for the handling of powdered fuel. The zinc driven off was only about 1%, but a marked increase in the temperature of the slag was observed. This would no doubt have reached 1,600° C., which was afterwards found to be so important a figure in all the tests. When this experiment was repeated the same results were observed. These tests anticipated the patent subsequently taken out, and in a great measure the new methods now being employed in one or two American and Japanese works, whereby powdered fuel is fed to the copper blast-furnaces through the tuyeres.

At a later period information was obtained from Europe, which led to the belief that the problem had been successfully solved there. Two processes were in operation: one using briquettes in a blast-furnace, the other utilizing the hot slag as it was tapped from a lead blast-furnace into a reverberatory furnace. In the latter operations two reverberatory furnaces were used, one of 20 tons and the other of 5 tons capacity. Into the former the slag was tapped from the blast-furnace and given a good strong firing. At intervals of 2½ hours the tap-hole was opened and enough slag allowed to run to fill the smaller or 5 ton reverberatory. At this stage a certain amount of limestone and coke was added, and the charge strongly fired for another 2½ hours. At the end of this period the zinc should have been expelled from the slag.

An experiment at Cockle Creek on the reverberatory method differed from the European tests in that only one furnace was used and the slag was introduced cold instead of hot. Charges of 10 tons were treated in this way, and a fair quantity of fume was expelled. One of the conditions necessary for the success of the operation was that the temperature should be not less than 1,600° C. A fair amount of fume came away while the slag was melting. A period of quiescence then intervened, when the fume came off again in large volumes, on the temperature rising to 1,600° C. Agitation of the charge helped considerably, but this agitation had to be continuous to be effectual. From assays taken it was found that from 35% to 40% of the zinc was expelled. The cost of working this method was, however, found prohibitive. A large amount of labour was necessary, and the quantity of fuel consumed in maintaining so high a temperature placed it beyond the possiblity of being a commercial success. Attention was next turned to the advantages offered by the electric furnace. A 350 k.w. motor-generator set, capable of giving 7,000 amperes at 50 volts, had been installed for treating zinc ores electrothermically. A small furnace was built of circular section, lined with 9 in. of English firebrick and holding about 500 lb. of slag. The top was left open so that the progress of fusion could be followed from beginning to end. Early during the test it was noticed that the action of the slag on the lining was very drastic, and at the end of six hours nothing remained of the furnace but the outer iron shell. As this was more of a preliminary experiment than an actual test, no figures were taken of power consumption or zinc extraction, though it was observed that dense volumes of fume were evolved. Numerous other linings were tried, including chrome and magnesite, but the experience gained was identical in each case; no refractory material could stand the intense heat and the action of the slag. Finally recourse was had to a water-jacketed furnace. A tank was therefore constructed, of trough form, 14 ft. long and 2 ft. wide, having a two-course brick lining, the idea being to have a furnace in which the molten slag would be kept in a state of flow, thereby endeavouring to establish a continuous operation. Four electrodes were introduced at equal intervals through the roof, the carbon tamping in the hearth making the

negative side. Cold slag was fed at one end, and, on fusing, travelled to the other end of the trough, having to pass three intensely hot zones on its way to the tap-hole. Continuous charging and tapping were maintained with excellent results, a large tonnage being treated with an extraction of 60% of the zinc in the slag. When the furnace was dismantled it was found that in the space formed, due to expansion, between the inner and outer lining of bricks, about half-a-pound of metallic zinc had condensed. This led to the conclusion that, under suitable conditions, it should be possible to condense the fume by the same operation, and thus save the additional cost of retorting. In order to collect the fume a new furnace was built, consisting of two concentric rings of boiler plate having a 3 in. water space between. A set of flues, connecting to a fan and bag-house, was erected and 10 tons of oxide collected. In appearance the oxide was somewhat grey, though occasionally there would be periods when the product from the bags would be nearly white. The carbon content explains the difference in the colour, but no reason can be assigned as to why it should be more prevalent at some periods than at others. The oxide produced by this method, it was observed, was of greater density than that recovered by the blast-furnace process of extraction mentioned later; it would be reasonable, however, to expect a good deal more occluded air in blast-furnace oxide than in that produced electrothermically. The following is a percentage analysis of the electric-furnace oxide: $PbSO_4$, 15·12; $PbCO_3$, 5·00; ZnO, 62·8; Fe_2O_3, 0·7; Al_2O_3, 2·21; SiO_2, 4·07; C, 0·93; CaO, trace; As, trace. In all cases a resistance type of furnace was used, this giving the highest efficiency. Besides using cold dump slag several tests were made on hot slag direct from the blast-furnace, as it was considered that by utilizing the heat already in the slag a great saving in power could be effected. The contrary was, however, found to be the case, as shorter time is required to remove the zinc from cold slag than when using it hot. Reducing agents and fluxes were discarded, as no advantage could be found to result from their use. There is no doubt that, given cheap power and a moderate price for graphite electrodes, the extraction of zinc from lead blast-furnace slags of low zinc contents could be looked upon as a commercial possibility, those usually run and experimented upon at the works containing about 9% Zn.

After a lapse of three years the question was again brought to the fore, and after careful consideration a small blast-furnace was constructed. Two rows of tuyeres were allowed for, 15 in. apart, with the bottom row 9 in. above the bottom of the furnace, the area at this point being 4 ft. 6 in. by 2 ft. 3 in. The depth of shaft from tap-hole to feed floor was 9 ft. 3 in., while above the feed floor a large chamber was built for the cooling of the gases before passing to the flues leading to the bag-house. The original tuyeres, 3 in. diameter, were found to be too large, therefore cast-iron thimbles were used to reduce the size to 1½ in. diameter. Soon after starting it was found that the two rows of tuyeres were rather a disadvantage, a careful balance in the blast pressure having to be maintained, otherwise a back draught was produced in the top row, which quickly destroyed the sleeves on the bustle pipe. At the same time an element of risk was run by the men attending the furnace when they opened the tuyeres, and as a consequence the top row was discarded. A 5 ft. charge column was found to give the best results when working with a blast of 8 to 10 oz. By these means it was possible to run the furnace with a hot top, while at the same time a minimum amount of dust was blown into the flues. From the cooling chamber the fume was carried along 30 ft. of brick flue and 180 ft. of 40 in. diameter iron pipe to a Fichter fume-collecting plant, and from thence to the bag-house. The Fichter plant, owing to the poor condition of some of the elements, on account of their having been idle for some years, did not collect much fume, but it answered the purpose of a cooler, the gases being so hot that the original arrangement, whereby the fume went straight to the bag-house, did not allow sufficient length of pipe and in consequence many of the bags were destroyed. The bag-house consisted of five rows of 12 bags, each 18 in. diameter and 17 ft. long. Two qualities were used, unbleached calico and grey flannel, the latter having the longer life. A by-pass was introduced between the furnace and the bag-house, by which means it was possible to divert the fume to the smelter stack, in the event of the bags requiring repairs or renewals. At the same time, as the capacity of the fan in use was not large enough to take all the fume, it was possible to run the furnace at full capacity, likewise preventing any fume from blowing through the charging doors, and interfering with the feeding.

In order to thoroughly test the method three distinct charges were used: slag briquettes, slag nodules, and ordinary dump slag. The first to be used were the briquettes having the following composition: Crushed slag, 100 parts; limestone, 15 parts; coke, 15 parts; cement, 1·5 parts. From the outset a great deal of trouble was experienced, through the friable nature of the briquettes, which broke up in the furnace and filled the crucible and tuyeres with fines. It was also found necessary to add an additional 26% of coke, part of which went to make up for the amount of fine coke blown out of the furnace. Quite apart from these mechanical troubles, however, the cost of making briquettes was found to be too high to ensure a profitable undertaking. In dealing with the slag nodules, all the above-mentioned objections also applied, but in spite of the many difficulties encountered, some valuable data were collected. The assay of the charge gave: lead, 3·6%; zinc, 7·8%. The zinc is on the low side, which is, of course, due to the dilution of the slag by the fluxes. The slag tapped ran on an average 0·5% lead and 3·2% zinc, the recovery calculated on these figures being 70% lead and 60% zinc. The high lead content of the slag is accounted for by the fact that it was taken from an old section of the dump. During all the operations a great deal of trouble was experienced through the formation of sows, but by building the crucible with a slope in the direction of the tap-hole, this trouble was overcome. The treatment of the nodules was a replica of the briquette campaign, only of shorter duration, giving practically the same results. Following the briquettes and nodules, a trial was carried out with slag direct from the dump. A certain proportion of limestone was added in order to run a slag going about 25% CaO. The following is the composition of the average charge: Slag, 100 parts; limestone, 17 parts; coke, 34 parts; with 2·3% Pb

and 9·8% Zn. The tapped slag went 1% Pb and 5·4% Zn. The recovery on these figures gives 60% Pb and 41% Zn. These results are low, but from data obtained while using a small quantity of slag rich in zinc, it was found possible to maintain a recovery of about 75%, and it was also found to be a comparatively simple matter to reduce the zinc to about 5%, regardless as to whether the original contents were 9% or 15%, so that, in running on a slag going 15% or 20% Zn, a fair margin of profit would be shown. About 40 tons of oxide of a blue-grey colour were collected which, on ignition, appeared creamy-white and gave the following percentage analysis: PbO, 25·42; ZnO, 63; CaO, trace; Insoluble, 0·70; SO_3, 8; Sb_2O_3, 0·13; As_2O_3, 0·85; Fe_2O_3, 0·28; CuO, trace; and Cl, 0·014.

From this series of tests certain definite data were established, showing that, in order to successfully recover zinc from lead blast-furnace slags, the zinc in the original slag should not be much below 15%. In addition it was found that a large proportion of the zinc is evolved during the process of melting; hence cold slag is preferable to slag in the molten state to commence with. The slag having reached the molten stage no more fume comes off until the temperature attains the region of 1,600° C or over. A lower temperature can be used, say 1,200° C, provided the bath is kept in a state of constant agitation during the whole period of treatment. These points concerning critical temperature were established through the medium of the electric furnace, which proved particularly suitable for this class of work, where a condition was required at all times that would permit of a close and constant watch being kept on the operations as a whole, but more particularly on the bath of slag itself. In order to carry the experiments through to a finality a small electrolytic zinc plant was erected for the treatment of the oxide. The plant was capable of producing about one ton of zinc per day and the whole of the oxide was converted to metal, which presented no difficulties in operating beyond those usually encountered in converting oxide to metal electrolytically, a high-grade zinc being produced.

MINING IN CENTRAL AUSTRALIA

In the *Chemical Engineering and Mining Review* (Melbourne) for March and April, E. Copley Playford, Chief Warden at Darwin, Northern Territory, gives an account of his journey from Adelaide to Darwin across the continent of Australia.

With the exception of a small and unprospected belt 80 miles south of Alice Springs, no metalliferous rocks are met with between Oodnadatta and the Macdonnell Ranges. Near Charlotte Waters, close to the Territory boundary, there exist deposits of kaolin, one apparently of great length and width, and of a very pure nature, from which aborigines obtain material to make smoking pipes and carved ornaments for the purpose of barter. An analysis of samples of clay taken by the writer from this deposit show the quality to be good and its behaviour, when burnt, fits it for use in high-grade ceramic ware. Arrangements have now been made to have a bulk parcel sent to the school of mines, Ballarat, where the Institute of Science and Industry is assisting in carrying out research work on clays of various types.

The Macdonnell Ranges consist of a series of jagged, precipitous, and, comparatively speaking, parallel lines of peaks, low jumbly hills and ridges rising from a plateau ranging from 2,000 to 2,500 ft. above sea-level, the mountainous and hilly country partly enclosing some extensive cotton and saltbush and grassy plains. These ranges trend in an easterly and westerly direction for about 250 miles with an average width of 45 miles, the overland telegraph line crossing them at their central and narrowest part. Apart from such crossing, the only sections passed over by the author were from Alice Springs via Undoolya station to the Arltunga goldfields, and from the latter locality via Winnecke goldfield, back to Alice Springs. The rocks, metamorphic and igneous, along the whole of the latter route, are favourable for the occurrence of gold, but except the auriferous areas mentioned and the Hart's Range mica field, very little prospecting work has been carried out throughout the Macdonnell Ranges.

The White Range, Arltunga goldfield, lies in the Macdonnell Ranges, about 60 miles E.N.E. from Alice Springs telegraph station, and 280 miles north from Oodnadatta railway station. The properties that have been worked comprise 16 gold-mining leaseholds with an aggregate area of 640 acres. With the exception of some of no great extent or depth on a claim known as the Joker, all mining operations that have been carried out on the White Range are within the boundaries of the leaseholds taken up by White, and nearly all are on its eastern slope, the majority being within an area of 80 acres. The principal ones, ranging from north to south, are locally known as the Great Western, Associated, White's East, and Lucy, with its continuation westerly known as the Pipeclay, White Range Consolidated, Excelsior, and Extended Nos. 1 and 2. There are also other mine workings on the higher slopes of the range and some near Corby's Bluff. Of these the most extensively worked are the Excelsior and Lucy, but in these two, as well as all the others, the ore has been simply rooted out at depths up to 70 ft. from different places in ore-channels, most of the workings resembling huge rabbit warrens with an occasional cave and burrows leading from them. The widest make of ore worked has a width of 15 ft., with no walls showing on either side, but in most cases the ore-bodies worked were from 4 to 6 ft. in width. According to the official records at the Arltunga government battery, the first parcel dealt with from the White Range was in 1898, and the last in August, 1913. Those from White's Blocks totalled 7,863 tons, the value of the gold recovered by amalgamation and cyaniding the sandy tailing was £44,780, an average result of £5 18s. 6d. per ton, equal to a return of 1½ oz. of fine gold. Only the sand and not the slime was cyanided, the recoverable value from such source being about one-fifth of the total. The value of the battery gold ranged from £3 8s. 3d. to £3 16s. 3d. per oz., the average being £3 12s. In the year 1914–15, 110 tons of this slime at this mill was treated by the government for a return from cyaniding of gold to the value of £402. The best parcel from the White Range was

ore of 1776 tons [illegible] at the Excelsior workings, which returned gold to the value of £3,548 12s. 6d. The values of [illegible] were very consistent, the last series totalling 627 tons for a return in value of £3,549. According to earlier expert reports, the proportion of material treated to that mined was from one-fourth to one-third, so that the gold recovered from the workings would average from 7 to 9½ dwt. per ton of material raised.

In close vicinity to the Blocks are two government wells, one 70 ft. in depth, with a fresh water supply of 150 gallons per day, and the other 150 ft. deep with a supply of 250 gallons. The other wells, all of which are government, within a radius of 5 miles of the properties are Police Camp well with a supply of 3,000 gallons; Paddy's Hole well, 1,000 gallons; Cross Road well, 250 gallons; Battery well, 5,000; and Whipe-Out well, 50 gallons of fresh water per day. The supply from these wells would be insufficient for an undertaking of any magnitude, and the only way of obtaining an ample supply, so far as can be foreseen, is by excavating a reservoir of large capacity in a clay flat near the Habe River, about five miles distant. There is only little gum and mulga in the creeks, the nearest mine timber of any importance being on the Habe River, and the quantity there is limited. Transport is by camel and horse team from Oodnadatta, the most direct route being from Deep Well, past Williams' Well (a stage of 70 miles, excepting shortly after rains), where the Alice Springs-Arltunga Road is met with. The climate is very healthy, with cold days and nights in the winter and hot days with cool nights in the summer. The rainfall averages about ten inches annually, falling mostly in the summer months, although good winter rains up to four inches are often experienced. There is very little, if any, suitable mine labour in the district, practically all the labour required for any mining operations having to be brought from south.

The gold-bearing formations cannot be termed lodes or reefs, and the only expression that conveys any idea of their character is ore-channels. Only the known richer places in them have been worked, but even so, should they go down, as they give every promise of doing, and retain their gold contents, the properties, when opened up in a systematic manner, may be of great value. Some of the formations can be easily and cheaply tested by means of tunnels from the eastern base of the range, one of the best sites for an adit being below the main workings of the Excelsior, where that formation could be driven into at a depth of 250 ft. below the workings and cross-cut by tunnelling a distance of 850 ft. Only in one of the workings was there any mineral detrimental to cyaniding, this being a small seam of copper ore containing arsenic in an underlie shaft on the Excelsior.

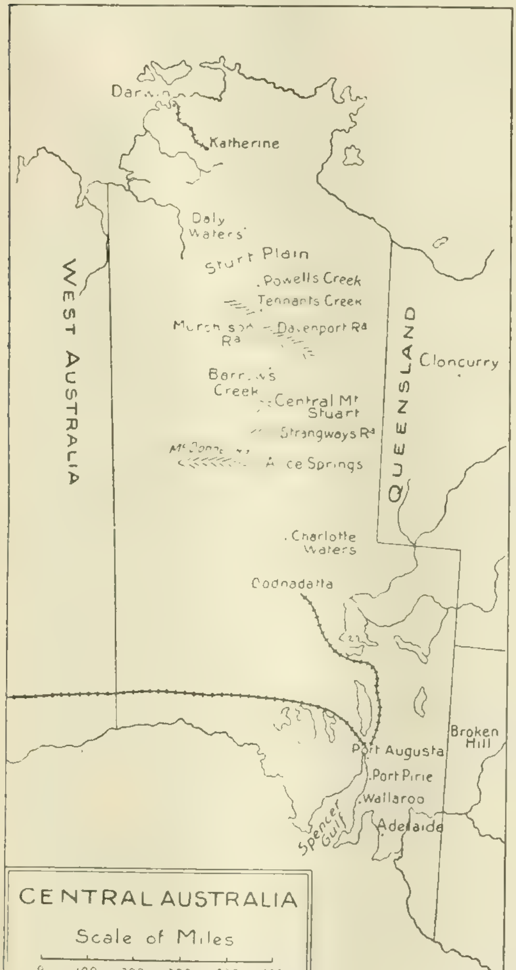
Twelve miles north from Alice Springs telegraph station the overland track passes through the ranges to an extensive, well-grassed plateau called Burt's Plain, having a gradual inland fall from 2,600 to 2,200 ft. above sea-level. For a distance of 40 miles the ranges are in close proximity to the east, but recede rapidly to the westward. Of this eastern branch of the ranges, known as the Strangways Range, Mr. Brown, the geologist, reports that the rocks consist of granite, syenite, diorite, and schistose granitic rocks with quartz reefs, and are favourable to the occurrence of gold. This definition also accurately describes and is applicable to the country passed over between Winnecke's goldfield and Alice Springs. From this range until the Buxton Ranges are reached only recent formation at a mean elevation of 2,200 ft. is met with, except at the low Hann Range, where primary rocks outcrop. In the Buxton Ranges are fair-sized areas of granitic country with slate carrying quartz, and ironstone reefs well worthy of being prospected for tin and gold. Galena was found at their western extremity. Thence along the track, passing Central Mount Stuart, the south-easterly end of the John Range, to the country near Barrow Creek, any rock formation that may exist is covered with recent deposits. The only information procurable of this high belt of country to the west is that contained in a government prospecting report of the party's rushing, in the year 1906, over then drought-stricken country in a futile attempt to reach Tanami. According to this record the mineral possibilities of the John Range, where the party saw a little copper ore and raised a colour of reef gold, appear to be fairly good, especially for gold, tin, and copper.

The few low ranges about and up to 30 miles north of Barrow Creek trend in an easterly and westerly direction. Nearly all are capped with quartzite, sandstone, and conglomerate overlying metamorphic granite and sandstone with slaty rocks and quartz reefs, which outcrop on their lower slopes. In the year 1919 an aboriginal discovered wolfram at the foot of the most southern one, called Foster's Range, and a ton or so of that ore was obtained and sent away. All the country then on to the outliers of the Davenport Range is recent and Tertiary, and of an average height of 1,500 ft. above sea-level.

The Davenport Range is one of the two most extensive geological features between Oodnadatta and Darwin. With the north-westerly extension, called the Murchison, their length is 150 miles with a breadth of 30 miles. The overland telegraph line and track crosses the extreme westerly end, where the ranges are low and narrow, and continues northerly for 40 miles at a few miles distance from the western margin of the Murchison Range. The prevailing rocks are sandstone, quartzite, conglomerate, and grit, which have formed flat-topped ranges of uniform heights to an altitude of 400 ft. above the surrounding country. Through denudation of this formation the older metalliferous rocks are exposed over large areas, the same agency having produced the numerous long, wide valleys that now exist between the ranges. During the years 1898–9 a party under the leadership of Mr. Allan Davidson prospected these ranges for gold. They discovered several auriferous areas, some fairly extensive, and put down shallow shafts on a few of the most promising gold-bearing reefs located, which were found to be too low a grade to be profitably worked under then existing conditions. As their main object was the discovery of rich gold reefs, only a little alluvial gold was sought for and obtained. The party also located some copper-bearing deposits, galena, common opal, and a mineral that was subsequently proved to be wolfram, when one of the party, subsidized by the government, revisited in 1914 the place of discovery. This field is now called Hatches Creek wolfram field, although it was about a year later before any mining work was done there.

Hatches Creek field is situated about 700 miles

from each of the termini of railway lines at Oodnadatta and Katherine respectively and 350 miles from the Duchess-Sullivan Creek railway, near Cloncurry, Queensland. The latter route is through waterless desert country for most of the way, but on account of the great disparity of distances it has, during the past three years, been used in preference to the Oodnadatta track. The wolfram belt runs in a northerly and southerly direction for a distance of 5 miles, its maximum width of 2 miles being at its southern end. Within this area are numerous wolfram-bearing quartz reefs, veins, and



short, irregular shoots from 1 in. to 4½ ft. in width with varying lengths up to 300 ft. The strike of the reefs is mainly in conformity with the country, and has a steep westerly dip. The enclosing rocks are metamorphic sandstone, quartzite, conglomerate, slate, and schistose granitic rocks, the two latter being principally at the northern end, where scheelite is the predominant mineral found, and where, in close proximity, there is a small auriferous area discovered by Mr. Davidson's party. The tungsten ores are very irregularly distributed throughout the matrix, being chiefly found in patches and shoots with stretches of barren material intervening; still in some of the reefs a run of fair grade ore is met with. Oxide of iron, a little copper, and bismuth, are associated with the wolfram at the southern end of the field. Mining operations, more or less of a perfunctory nature, were profitably carried out on this field from the year 1915 up to when the price of wolfram slumped early last year. By that time the deepest working was 117 ft. from the surface. Only a few men, and those at a high rate of wages, or if preferred by the employee, on a good term of tribute, could be induced to go there. At no time were there more than fifty Europeans on the field, and at the time of the writer's visit in September last they numbered only sixteen, the majority of whom were about to leave. The output of the field to date is about 250 tons of 66% wolfram ore and 25 tons of scheelite at a little higher percentage, all, with the exception of some alluvial, obtained by burning and dollying the material mined.

Another important wolfram field, known as Wauchope Creek, is also situated in the Davenport Range, about 60 miles N.N.W. from Hatches Creek, 6 miles easterly from the overland telegraph line and track and nearly midway between Oodnadatta and Katherine. In the year 1917 an aboriginal engaged in horse hunting discovered wolfram there, and shortly afterwards the whole of the wolfram-bearing area comprising a small parcel of land 50 by 20 chains was pegged out in small holdings. These latter are in a small metamorphic sandstone and slate belt about 3 miles in length and from a chain to 20 chains in width, trending N.N.W. and S.S.E., bounded on the east by a table-topped range of desert sandstone, and west by a line of low hills and ridges of quartzite bordering on scrubby plain country lying immediately to the south-west. Within this belt at its central and widest part are a series of wolfram-bearing quartz reefs and leaders from 1 in. to 2 ft. in width outcropping for distances up to 800 ft. Their uniformity is remarkable, and the majority of them trend with the country and have a flattish dip to the north-east, gradually becoming steeper so far as worked down. Wolfram ore of good grade was obtained in places along quite a dozen of the principal reefs and for long distances in some of them. Mining operations carried out are of the nature of irregular open-cuts, very little of a systematic nature having been done. The deepest of the few shafts sunk is only 40 ft. from the surface. Where rich stone was showing on the surface it was simply rooted out, and when such a patch became poorer, another was found and dug into. The richness of some of these was phenomenal, men on tribute obtaining as much as 8 tons of clean wolfram for three or four weeks' work. As at Hatches Creek, operations were handicapped through want of labour. At no time were there more than 26 Europeans on the field, all but five or six of them being wage and tribute men. Want of water was also a drawback, the nearest permanent water supply being 16 miles away; moreover, all transport was by camel team to and from Oodnadatta, 600 miles distant. Notwithstanding these disadvantages and the occurrence of a four months' strike of wage and tribute men, the claim-holders made net profits of many thousands of pounds out of wolfram obtained from their mines during the short period of work. At the time of the author's re-visiting the locality in September last, the holdings were under exemption from labour conditions, and only

two Europeans were there. Some nice wolfram was then showing on the face at different workings. So far the field has proved to be exceptionally rich in wolfram, and there is every promise of continuance and the reefs living to great depths. The output to date is approximately 237 tons of 68% wolfram ore, all perfectly free from any detrimental substance, and obtained, except when mined in solid lumps and alluvial, by burning and dollying wolfram-bearing quartz. Very recently the majority of these mine holdings, including the principal leases, have been acquired by an Adelaide company with £12,000 working capital.

Prior to Mr. Davidson's party, no prospecting work was carried out in these ranges, and the little that was done subsequently was solely for wolfram, a small quantity of that mineral being found a mile south from Woodineera waterhole in the Frew River, 40 miles to the north of Hatches Creek, at the head of Lennie Creek, mid-way between the two fields, and in some quartz veins and alluvial at the Marbles, 8 miles northerly from Wauchope. Although areas of granite country have the appearance of being stanniferous, the only discovery reported was of a few ounces of black tin ore from gully wash near Wauchope Creek.

Since the author's course was along the ranges from Hatches Creek to Wauchope Creek, mostly through trackless country, the Kurrundie gold reefs were not visited. These are close to the Hatches Creek-Tennant's Creek track, and, according to Mr. Davidson's report, are large, low-grade propositions payable to work under favourable conditions. Since his party left nothing further has been done there, although from time to time the areas have been taken up solely for speculative purposes.

Along the overland track, after leaving the Davenport Ranges, past Kelly's well (1,100 ft. above sea-level) to the McDouall Ranges near Tennant's Creek, undulating sandy country is passed over for most of the way, the older formations of metamorphic sandstone, quartzite, and granitic rocks with quartz veins being only met with at the westerly outliers of the Murchison Range. The McDouall Ranges are actually a continuation of and a westerly branch of the Murchison Range. No eruptive rock was seen by the writer in passing through them, but in every other respect they appear to be of similar formation ; their maximum height does not exceed 1,600 ft. above sea-level.

After leaving Tennant's Creek there is no metalliferous country until the Marranboy tin belts are reached. Patches of broken tableland, continuations of similar higher formations to the westward, are between Attack and Woodforde Creeks on the Tennant's-Powell stage, and also between Powell's Creek and Newcastle Plains ; the rocks are desert sandstone, quartzite, and conglomerate, lying very flat. At Banka Banka station, 20 miles from the western edge of the Barkly Tablelands, there is some coarse, acid, grey granite. A little opalized quartz was observed between Banka Banka station and Helena Springs, where opal was discovered. Outcrops of acid, grey granite, and coarse conglomerate occur between Sturt's Plain and Daly Waters. From then on to the stanniferous country mentioned, recent and Tertiary formations overlie limestone, as in the Barkly Tableland, but nowhere in this long stretch of country—some 400 miles—is there any likelihood of a mineral find being made.

From Marranboy the author travelled via Maude Creek old gold and copper diggings, 40 miles to Katherine, thence by train to Darwin. As these two mining fields are well within the coastal district, and, with others similarly situated, have been described by geologists and other officials, and as the conditions pertaining to such are totally dissimilar to those inland, it is not necessary to refer to them here.

The metalliferous areas described and commented on in this article are, with the exception of Tanami and the Petermann Range—where a few colours of gold were found—all those known outside the territorial coastal belt. They are on these uplands extending from the 19° 30′ to the 24° parallel of south latitude, and from 200 to 300 miles from the border line between the Northern Territory and Queensland. Only small portions of this huge area of country have been prospected, and that mostly in a haphazard manner. Past and existing conditions and circumstances offer little, if any, inducement to the prospector, and the great distances from rail and centres of population, combined with the costly, slow, and unreliable transport facilities, practically prohibit the development of any of the known mines, even by companies with a large working capital.

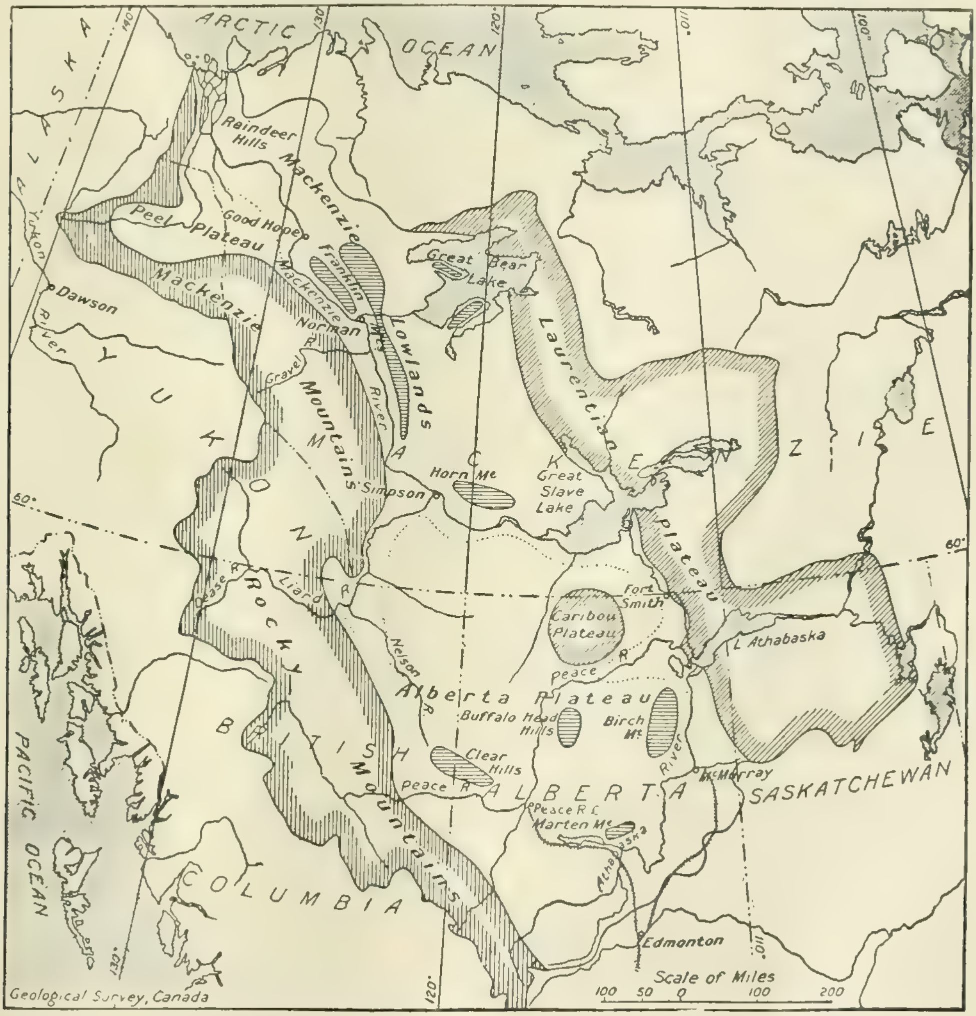
The climate over the whole area is very healthy, with hot dry heat in summer, cool days and cold and often frosty nights in the winter. The average annual rainfall, which is somewhat irregular, is about 10 in., falling in heavy showers in the summer, the winter rains being of a drizzly nature, accompanied by cold easterly winds. There is nothing in the nature of the climate to retard European labour efficiency to any appreciable extent. In no sense is the country tropical or semi-tropical, and malarial and other enervating disorders prevalent on the coastal mining fields are unknown. Timber for mining purposes is scarce over all the metalliferous areas, the trees on the ranges and hills being hollow, stunted, and scattered, and only fit for firewood. Good mine timbers of mulga, bloodwood, and gum are obtainable in limited quantities in the valleys of creeks and so-called rivers, and from the surrounding country. Water is scarce throughout the Macdonnell Ranges. There are a few large waterholes and springs, and a limited supply is obtainable by sinking in some of the creeks to depths up to 100 ft. For any big mining undertaking, however, water would probably have to be stored in dams or reservoirs. In the Davenport Ranges there are numerous waterholes, some very long and deep and practically permanent. Along the telegraph line north from Alice Springs (which is a misnomer, as there are no springs there) fair supplies of water have been struck at shallow depths in some of the government wells. It would therefore appear that any water difficulty would not be of a serious nature, and could be easily overcome by conservation.

As regards a route for the proposed north-south continental railway, the direct route to connect the present termini—Oodnadatta and Katherine—is via Arltunga through the Hart's Range mica field, not anywhere near Alice Springs, as most people seem to think, then on past Wauchope Creek wolfram field. For engineering and other reasons, however, a deviation from Arltunga in the direction of Hatches Creek, and then through the north-western portion of the Barkly Tablelands may be preferable.

OIL PROSPECTING IN THE MACKENZIE RIVER DISTRICT

The *Canadian Mining Journal* for May 6 prints an article by E. M. Kindle, of the Canadian Geological Survey, containing a number of suggestions to oil prospectors in the Mackenzie River Valley. The opening of navigation in the Mackenzie River basin this season will probably witness a northern migration of oil prospectors, unprecedented in western Canada. A large proportion of those who are likely to make the long journey to the new oil-field below Norman on the Lower Mackenzie will probably have little or no knowledge of the conditions under which they must live in this region. A few suggestions and some bits of geographical information from one who has spent two seasons in the Mackenzie Valley will be helpful to many who go into the great Northland for the first time, and also to many others who do not.

While prospectors will find a genial summer climate, they will need to provide with some care for the sub-Arctic winter conditions which follow the summers. One of the most important of these provisions for winter is a cabin. It should be clearly understood that there are no road houses or other establishments furnishing public accommodation anywhere in the Mackenzie Valley. The environment of the North exercises a selective influence on the human as it does on the other kinds of animals found within its bounds. The man who lives in the North as a trapper must in winter be able to visit his traps and sleep in the open at a temperature of 60° below zero. Losing a trail in the spruce forests is likely to mean freezing in winter and starvation in summer. He must have a keen sense of direction and the ability to estimate accurately the limitations of his canoe. An error in estimating the hazard of a rapid or the strength of a gale results in his elimination from the field of adjustment to northern conditions. So the white men whom one meets on the northern rivers and lakes represent as a rule a selected group of men who have proved themselves fit to cope with conditions which quickly weed out the human weaklings.



MAP GIVING AN OUTLINE OF THE PHYSIOGRAPHY OF THE MACKENZIE RIVER BASIN.

Edmonton is the logical place for outfitting if one wishes the advantages of large and well-stocked stores, but most of the provisions required for an expedition into the North-West Territories can be obtained either at Peace River Crossing or McMurray. At one or the other of these points the north-bound traveller takes final leave of railways and hotels and must be prepared to depend entirely on his own resources. After provisions the next most important items for the outfit are one or two heavy woollen blankets or some form of sleeping-bag and a mosquito-proof tent. No experienced man will neglect the latter, and the nearly equally important items of light-canvas gloves and head nets in outfitting for any part of the northern wilderness. He who neglects these precautions against the universal mosquito pest of the North-West will have good cause to regret his negligence and probably decide that he would have enjoyed just as much a sojourn in the super-heated climate of tradition.

One of the things which should be included in the outfit of the prospector going into the Mackenzie basin in a geological map of the region. This may be obtained by writing the Director of the Canadian Geological Survey at Ottawa for a copy of Memoir 108. Another small but important item of the outfit is a pocket compass. The north-bound traveller may be reminded here that his compass readings require correction as he journeys north in somewhat the same way as does his watch on a transcontinental trip. At Fort Smith the needle points not even approximately north, but 33° 23′ east of north. At Fort Norman the declination east is between 41 and 42 degrees.

Any approach by rail to the Peace or Athabasca rivers, which are the great waterways leading toward Great Slave and the Mackenzie, must be through the city of Edmonton. This thriving modern city was a very few years ago only an obscure trading-post of the Hudson Bay Co. on the Saskatchewan River. A railroad was completed a few years ago from Edmonton to Peace River Crossing on the Peace River, which is about 312 miles north-west of Edmonton. Another railroad extends north from Edmonton via Lac La Biche to the head of navigation on the Clearwater River. This railway ends near McMurray ; from that point to the Arctic coast steamer navigation on the Mackenzie is interrupted at but one point, the rapids at Fort Smith, where there is a portage of 16 miles. It should be noted, however, that while the latter route is the most direct the service beyond Lac La Biche is frequently discontinued for considerable periods because of the condition of the road bed. The Peace River route is longer and involves a four-mile portage at the Vermillion chutes which the McMurray route avoids, but the railway transportation is more dependable. The distance from the end of the railroad at Peace River Crossing to the oil well is about 1,500 miles, and from McMurray about 1,200 miles. Telegraph service extends to Peace River Crossing and to McMurray, but not beyond.

Two lines of steamers have for a number of years been engaged every summer in bringing out the winter catch of fur and taking in the yearly consignment of supplies to the trading posts which are located from 100 to 200 miles apart throughout the Mackenzie River system. A third line began operations in 1919. These steamers make only a single round-trip to the most northerly posts. Two or more trips are ordinarily made to points on the Upper Mackenzie. The companies operating steamers on the Mackenzie in 1920 were the Hudson's Bay Co. and the Northern Trading Co. Both of these companies have offices in Edmonton. The round-trip steamer rate quoted by one of the transport companies this season from McMurray to the oil well, including meals and berth, is $300. A freight rate which has been quoted between these points (north) is $10·25 per 100lb. During the winter season the only communication between the Mackenzie Valley and the outside world is maintained by dog sledges or carioles which carry the mails in and out of the Mackenzie Valley once a month. Only first-class mail, however, is carried on these. It may well be understood that to the inhabitants of the Mackenzie Valley the great seasonal events of the year are the opening and closing of navigation on the waterways of the basin.

The ice of Great Slave Lake blocks the navigation of the Mackenzie River for nearly a month after the great river is free of ice. Owing to this fact navigation on the Mackenzie is limited to about 3½ months. The record of the ice break-up at Rae on Great Slave Lake entered in the Hudson's Bay Company journals and published by Russell shows the break-up during 6 years (1857-9 and 1883-5) to have ranged from May 30 to June 23. The general direction of the wind in spring, however, drives the ice toward the southern shore so that steamers seldom venture into the lake before the first of July.

The Mackenzie at Simpson, which is near latitude 62°, opens between May 4 to May 20, averaging from the 10th to the 15th, according to Captain Mills, who has spent several years at Simpson and has run steamers on all of the navigable waters of the Mackenzie basin. Because of nearly dead water in the Mackenzie for a long distance, the head of the river opens 2½ or 3 weeks later than at Simpson. The opening of Great Slave Lake generally occurs, according to Captain Mills, between June 16 and July 2, or six weeks later than the Mackenzie below Simpson.

Fur constitutes the sole commercial product of the country, and prospective travellers in the Mackenzie Valley may be reminded that the transport companies were established solely for the purpose of getting the fur out of the country, and a limited amount of provisions in each season to the trading posts, not for the accommodation of the travelling public.

The approximate distances between the trading posts on the Mackenzie River system north of the end of the railroad at McMurray are indicated in the following table :—

From McMurray to	Miles.
Fort Chipewyan	190
Fort Fitzgerald	280
Fort Smith	296
Fort Resolution	490
Fort Hay River	570
Fort Providence	660
Fort Simpson	835
Fort Wrigley	995
Fort Norman	1,155
Oil Well	1,201
Fort Good Hope	1,330
Fort Arctic Red River	1,570
Fort McPherson	1,635
Fort Scenic	1,735

A company has been organized which proposes to build a railway around the Slave River rapids between Fort Smith and Fitzgerald. At present,

however, all freight must be transported across the 16 miles between these two points by wagon or tractor. Steamers will leave Fort Smith for the first trip down the Mackenzie about June 24. Departure from the same point on the second trip will be about July 26.

The Mounted Police have the authority to turn back any individual whom they consider for physical or other reason unfit for the trip. The inspector at Fort Fitzgerald, which must be passed by all persons entering the Mackenzie Valley, is required to take certain personal information regarding each individual going beyond that point. This interview may include a request for evidence that arrangements have been made with some power-boat for return transport or that a contract for a year's supply of provisions has been secured. It is necessary to begin the return trip from Norman not later than September 28 if a winter sojourn is not planned.

It is reported that aeroplane service to the new oil district will be available for those who do not mind paying $1,000 for the round-trip. The Imperial Oil Company is preparing to use planes for the purpose of taking in its own employees.

It is probable that many persons wishing to go north this season will find it impossible to secure accommodation on the steamers. Such persons will, however, find it possible to make the trip north by canoe, and to make very good time with the aid of the river current. The return trip, of course, cannot profitably be made in this way, since the journey is up stream. A man skilful with tools can build his own boat on the river bank at Peace River Crossing.

In the northern latitude where daylight lasts about 24 hours in June it is feasible for large canoes to travel day and night if the party wishes to speed up. The mosquitoes are less active during the cool nights, which is often another incentive to night travel. The writer has covered the 200 miles stretch between Fort Smith and Resolution by day and night travel in 2½ days. This method for short periods involves no hardship, if the night is divided into two or more watches with only one man at the paddle, while the others sleep or study astronomy from the bottom of the canoe. There are only two points on the entire Mackenzie River where the canoeman needs any special advice in regard to avoiding rapids. One of these is opposite the site of Old Fort Wrigley. Here the river splits on a rocky island. Loaded canoes and scows should take the west channel. The narrow eastern channel is rather swift water. The other locality is the Sans Sault rapids. Here also the canoeman should take the west side of the river keeping near the shore. The Vermillion chutes and the Smith rapids on the Slave are always portaged.

The Mackenzie basin embraces a vast area representing some 680,000 square miles of territory in North West Canada. Extending over nearly 17° of latitude it necessarily includes a considerable variety of physiography. A great central plain bordered on the east by the Laurentian plateau and on the west by the Rocky mountains and their northern extension, the Mackenzie Mountains, represent the major physiographic features of the region. The mileage of the new oil well is equivalent to the distance from Ottawa to South Florida. Since there are no roads and very few trails, travel in the Mackenzie Valley is strictly limited to the waterways. Everywhere dense forests of spruce and poplar, muskeg, or small lakes cover the lowlands near the rivers. These generally render travel across country nearly impossible or extremely slow. In all the 1,200 mile stretch of lake and river between the end of steel at McMurray and the oil well, the traveller will see only eight or ten Indian villages, with two or three fur-trading stores at each to interrupt the virgin forest. The total population of the entire Mackenzie district will probably not exceed 5,000. Probably less than 150 of these are whites, the remainder being Indians, except 200 or 300 Esquimaux.

Oil in Saskatchewan.—The throwing open of the Pasquia Hills Forest Reserve for oil prospecting under the recent amendments to the Dominion Oil Regulations, has drawn attention once more to this potential oil region. To readers of the MAGAZINE its position is best indicated by recording that it is about 40 miles from The Pas over the Saskatchewan-Manitoba border. The presence of large bodies of oil shales in these hills has long been known. In the course of his report to the Geological Survey on the basins of the Nelson and Churchill Rivers, William McInnes made several references to these shales. His report, which was written in 1911, was published two years later as Memoir No. 30. The *Canadian Mining Journal* for April 8 gives extracts from this report.

According to Mr. McInnes the overlap of the Cretaceous sediments is marked for a hundred miles west of Lake Winnipegosis by the bold escarpment of the Porcupine and Pasquia Hills, and farther west by the equally high but gently sloping Wapawekka Hills. A partial section of Cretaceous rocks making up the Pasquia Hills was seen where the rocks are exposed in gullies worn by streams descending these northerly facing slopes. An estimated section along these gullies, compiled mainly from exposures observed in the trench worn by Nabi River, is as follows, in ascending order :—

35 ft. to 40 ft. ; thick bedded, soft grey arenaceous oil-shale or thin bedded sandstone, holding the remains of fishes.

6 in. ; compact impure limestone.

120 ft. or more ; soft, fissile, light grey (almost black when wet) oil-shales, holding the comminuted remains of fishes and many foraminifera.

15 ft. ; clay iron-stone in beds 6 in. to 1 ft. in thickness, divided by thin partings of shale.

10 ft. ; soft fissile, grey shale that seems to be similar to the oil-shales below.

The whole is overlain, to the surface, by 10 ft. or more of boulder clay containing many boulders of limestone and a few of Pre-Cambrian gneiss and granite.

The fossils from the section given above were probably of Niobrara age. The thickness of the Niobrara in Manitoba has been computed to be from 130 to 200 ft., comprising calcareous shales, which pass downwards into the shale of the Benton.

The base of the section given above lies at a height of 400 ft. or more above the bed of the Carrot River, where, at the rapid above the Red Earth Indian reserve, ledges are exposed that are thought to represent the Dakota division of the upper Cretaceous. They consist of 5 ft. of very soft quartzose sandstone deeply stained with iron oxide, lying in undisturbed heavy beds that show false-bedding, and hold nodules and irregular masses of iron pyrites. In places the sandstone becomes a fine conglomerate,

in certain layers with pebbles of gneiss and other rocks, and in places it contains carbonaceous material resembling the comminuted remains of plants. The soft sandstone is overlain by hard, white quartz sandstone with distinctly red-purple tinge, which is strongly ripple-marked on some surfaces.

Fifty miles farther up the Carrot River from the rapid at which the sandstones are exposed, and at an elevation of about 400 ft. above that point, grey oil-shales similar to those of the Pasquia Hills section form the low scarped banks of the river. There is thus an interval of 400 ft. or more between the observed beds of Dakota sandstone and those of Niobrara shale. A great part of this interval, which on the side of the Pasquia Hills and in the valley of the Carrot river is covered by deposits of boulder clay and by later stratified sands and clays, is without doubt occupied by the shales of the Benton. Shales considered to be of Benton age which, from their relative elevation, would fall into this gap, were observed by Mr. J. B. Tyrrell in the bed of the Saskatchewan below Birch islands.

The Carrot river, which joins the Saskatchewan two miles above The Pas flows past the Red Earth Indian reserve. From the crossing of the second base line westerly, the steeply sloping front of the Pasquia Hills rises from the flat land to the south of the river all along. The hills rise to a height of about 1,600 ft. above the valley or 2,500 ft. above the sea. The hills are made up for the most part of Cretaceous sediments, though the base is probably formed of Palæozoic beds and the summit is covered by varying thickness of boulder clay.

The only exposures of rock in place seen in the Pasquia Hills by Mr. McInnes were found in the gulches eroded by streams flowing down the hill-slopes. They consist for the most part of soft, grey, fissile shales that contain a considerable amount of bituminous matter, enough to cause them to burn freely, with the emission of a strong odour of petroleum when heated in the camp fire. The best exposures were found in the valley of the Nabi river, where 140 ft. or more of thick-bedded sandstone, holding the remains of fishes, bivalves, and foraminifera, are exposed in cliffs along the river; the species are characteristic of the Niobrara division of the Cretaceous.

Altogether more than 40 square miles of territory in the Pasquia Hills have been staked since December last, when the new oil regulations came into force. Syndicates have been formed and it is understood that several drills will be on the spot at an early date. A miniature boom is, in fact, being staged, and local hopes of a future producing oil-field are high. Expeditions have been sent out by business men from The Pas, while interests in cities in western Canada have put up money for exploration work. Many samples of shale have been brought into The Pas, which when lighted will burn freely. Samples of paraffin wax and fossilized remains of fish are also on view. The break-up of frost has interfered with traffic between The Pas and the Pasquia Hills for a time, and it is unlikely that any further parties will venture out until open water, when it is anticipated there will be a big rush to take up sections. The Pasquia Hills are reached in the winter time by horse team and dog sleigh, and in the summer there is a water route running into the foothills, from whence the best method of travelling will be by pack horses. Since the above was written, many parties have gone into the region.

Zinc Determination.—In the *Journal* of the Society of Chemical Industry for May 31, E. Olivier, writing from the Central Laboratory of the Vieille Montagne Company, discusses the determination of zinc by the potassium ferrocyanide method. The determination of the zinc content of Australian concentrates is usually carried out volumetrically, either by the so-called American method (the potassium ferrocyanide method) or by the Schaffner method (titration of the ammoniacal solution with sodium sulphide); this last method is also sometimes termed the Vieille Montagne method (see Frevet, *Bull. Soc. Chim. Belg.*, 1919, 28, 351). In the American method, as usually carried out, the ore or concentrate is decomposed by means of nitric acid and potassium chlorate, the mixture evaporated to dryness, the residue boiled with ammonia and ammonium chloride solution, and the filtrate acidified; the copper is removed by means of lead foil, the liquid is neutralized with ammonia, a solution of potassium hydrogen tartate and ferric chloride is added, the solution heated to about 75° C., and titrated with standard potassium ferrocyanide solution in presence of ammonia until a spot test with acetic acid shows a blue coloration. The method used for preparing the solution for analysis results in the extraction of the zinc, together with the copper, cadmium, calcium, and magnesium, and part of the lead, iron, and manganese. Of these elements only the zinc, copper, cadmium, and manganese are precipitated by the ferrocyanide, and only the copper is removed prior to the titration, so that the cadmium and manganese present are returned as zinc. While the amount of cadmium present in the concentrates is usually so small as to be negligible (it averages about 0·1%), this is not so in the case of manganese, which may be present to the extent of considerably more than 1%, and so result in a high figure being returned for zinc. In one case, for example, the author found 1·16% of manganese (as Mn_3O_4) in the zinc solution before titration. That amounts of manganese such as are found in concentrates vitiate the titration is shown by experiments in which manganese corresponding to 2% and 4% respectively of Mn_3O_4 was added to solutions of known zinc content; on titration of these solutions, 0·8% and 2·3% of zinc in excess of the quantity present was indicated. To separate the manganese completely from the solution, a few cubic centimetres of hydrogen peroxide are added to the mixture of ammonium chloride solution and ammonia used to treat the residue resulting from the decomposition of the ore; this renders the manganese insoluble, and the results obtained agree closely with those found by the Schaffner method. When the percentage of manganese present is small (for instance 0·25%) the results obtained by the two methods (without the use of hydrogen peroxide) agree within about 0·1%, but in most cases manganese will be present in amounts sufficiently great to necessitate the use of hydrogen peroxide. The American method has another disadvantage, especially where a large number of titrations have to be made daily, namely, the titration is carried out in hot solutions; this is necessary in order to obtain complete precipitation of the zinc ferrocyanide in a dense, gelatinous form. Further, the blue coloration produced in the spot test is not entirely satisfactory, since although the reaction is sensitive the colour is not always very distinct in presence of coloured

ferrocyanides and the intensity of the colour is not appreciably increased with increasing amounts of potassium ferrocyanide. In the author's opinion the Schaffner method is preferable to the American method, in view of the above facts, and also having in mind the fact that the zinc is precipitated as colourless sulphide, which affords a ready indication of its freedom from other metallic sulphides. The only other colourless insoluble sulphide known is the double sulphide of zinc and cadmium, discovered by the author in 1886, but the error arising from this source is negligible since, as already pointed out, zinc ores contain very little cadmium, and, moreover, the greater part of the cadmium is separated as sulphide together with the lead and copper.

Solution and Deposition of Iron.—The *Journal* of the Society of Chemical Industry for May 16 contains a paper by J. Haworth and J. Evans entitled "The Ochre Streams of the Valleys of the Don and Loxley, South Yorkshire". The paper dealt primarily with questions of water supply, but it is of interest to geologists also, as it refers to bacterial action in depositing iron.

The authors define ochre waters as natural waters in which salts of iron occur in solution. In most cases such waters deposit iron oxide or ochre on the banks and bed of the stream. They may be conveniently sub-divided as: (1) Chalybeate waters, which occur either as waters containing carbon dioxide and iron bicarbonate, together with other salts, or as saline acidulous chalybeates containing chiefly sodium sulphate and iron bicarbonate; and (2) waters containing chiefly sulphates of iron. The chalybeate waters seldom contain large quantities of iron (8 to 15 parts per 100,000). They emanate from strata containing iron in the form of carbonate, which in the presence of carbon dioxide forms the soluble bicarbonate. Waters containing sulphates of iron are frequently found in all districts where coal workings exist or where outcrops of the coal measures occur. The streams in valleys draining areas in which coal measures are exposed frequently bear marked indications of the presence of iron salts by the brown and red deposits of ochre on the beds of the streams and by the brown colour of the water.

The River Loxley is a tributary of the Don, and the watersheds are divided by a precipitous ridge in which outcrops of the lower coal measures occur at numerous points and are exposed. Beneath the lower coal measures beds of ganister and fireclay occur. These are worked at numerous points on both sides of the ridge, the products being largely used in the Sheffield industries. The mining operations consist usually of driving levels or adits into sides of the valleys at different levels where the outcrops occur, and water drains from these forming streams which flow down to the river. There are also other streams flowing from the slopes of the valley, but a casual observation shows that the streams from the mines or ganister pits all contain salts of iron and deposited ochre, whereas the remaining streams contain no iron. The physical appearance of the ochre streams is striking. In some cases the water is clear but coloured, the colour varying from pale yellow to a deep reddish-brown; in other cases the water is turbid through the presence of iron hydroxide, but in all cases heavy deposits of iron hydroxide or basic iron sulphate are present. The source of iron salts is without doubt iron pyrites between the layers of the coal strata. Specimens of the shale and coal when first exposed show distinct layers of pyrites in the course of oxidation; in splitting the layers perfect crystals of transparent calcium sulphate in the form of selenite, $CaSO_4, 2H_2O$, may be observed. This substance also finds its way into the water. The waters issuing from the mines contain ferrous and ferric sulphates, and free sulphuric acid, the primary oxidation products of pyrites. In the streams further reactions occur producing the heavy red deposits which consist of ferric oxide and basic ferric sulphates. In some cases the banks consist of this deposited ochre for several inches in depth.

The ochre deposits have their origin in several ways: (1) Direct oxidation and the production of ferric hydroxide; (2) alkaline surface waters joining the stream; (3) the action of iron bacteria which grow profusely in such waters. The first two methods of deposition are purely chemical; the third is of considerable interest. Water containing iron salts, even in very minute quantities, forms a very suitable medium for the growth of the organisms commonly referred to as "iron bacteria"; two common varieties of these are *Crenothrix polyspera* and *Leptothrix ochraceæ*. As little as one part of iron in 2 to 3 millions of water is sufficient to permit the development of these organisms. The organisms decompose the salts of iron, depositing the iron in the form of ferric oxide, and liberating acid. In the case of ochre streams such as those under consideration the organisms deposit the ferric oxide and the streams become acid. The organisms have very high chemical energy and are able to oxidize ferrous salts many times the weight of their own cells. They are remarkable by reason of the fact that their existence is maintained largely by inorganic salts and the presence of only minute quantities of organic matter is necessary. In the case of the two rivers mentioned the usual flora and fauna are entirely absent.

Rod Grinding Mills.—In the *Engineering and Mining Journal* for May 28, E. H. Robie discusses the development of the rod-mill, that is to say, the form of re-grinding mill in which rods are used instead of balls or pebbles. He gives particulars of the Marathon, Marcy, Allis-Chalmers, Cole-Bergman, and Forrester-Hendy types, and also accounts of experimental work done with them. We quote herewith some of his views founded on his investigations and experience.

Rod or roller mills are being actively developed by several companies and have every possibility of being successful competitors of ball and tube mills in certain fields of work. They are adapted only to grinding through a comparatively narrow size range in individual mills, and work done up to this time indicates that they cannot take feed as large as is often given to a ball-mill, nor is it yet proved that they are superior or equal to tube-mills where material finer than 100 mesh is desired. Theoretically, however, there is no reason why they should not be efficient grinders for the finest sizes. They do not seem as adaptable to small as to large units, for a small mill could not carry sufficient weight of rods to break up large or tough ore particles, for the rods act along a line contact. They have been successfully used for dry crushing, although this is not generally desired. There seems to be no reason why rods could not be substituted for balls in mills of the Krupp type which discharge through perforated plates forming the cylindrical surface of the mills. The author has never heard of

[illegible] the way, however, removal of the worn rods would be an inconvenience.

In rod-mills, a waved type of liner is probably [illegible]. The indications are that liner consumption will be possibly ½ lb. per ton less than for ball-mills. Also, the forms are simpler and can be made more cheaply. There are no grates or manholes to provide for. The consumption of steel rods appears to be slightly less in the rod-mill than of balls in the ball-mill. In this connexion it is important to remember that steel in the form of rods or rounds is a standard article, cheaply made, and obtainable from many rolling-mill plants. Competition is active, and there are no trade-name handicaps. Statistics covering several years indicate that balls sell for about double as much as rods. Freight, however, will be perhaps half of the delivered cost and is about the same for rods as for balls. Power consumption would seem to be somewhat less as a general rule for rod-mills than for ball-mills of equal capacity, the exact figures depending upon the grinding problem and the type of mill selected.

Indications are that flotation concentrates are more easily filtered when the ore has been ground in rod-mills than when balls have been used as the grinding medium. If this be true, it would seem to be a logical result of the lessened amount of slime produced in rod-mill grinding, inasmuch as it is this which clogs the canvas and results in a thin and wet filter cake.

Most of the rod-mills described by the author have not been in use long enough to prove the extent of their applicability or to afford fair comparisons with ball-mills or tube-mills. The information given indicates possibly more of their advantages than disadvantages.

Origin of Graphite.—In *Economic Geology* for May, Thomas H. Clark, of Harvard University, discusses the origin of graphite at the contact of igneous and metamorphic rocks. He quotes a paper by K. L. Alling appearing in the New York State Museum *Bulletin* for 1918. Alling showed that the oxides of carbon in the presence of gaseous water may react to form graphite. Much of this water may be magmatic, or the heat of the intrusive igneous rocks may release water from sedimentary rocks ; while one of the sources of carbon dioxide may be calcium carbonate. The author also quotes H. P. H. Brumell's paper in the *Journal* of the Canadian Mining Institute, 1908, who suggested that intrusives, in conjunction with siliceous or other waters, acted upon the original rocks, and formed sulphates and silicates, at the same time depositing the carbon as graphite. The author proceeds to discuss opinions on the subject of A. N. Winchell, H. Dixon, and E. G. Acheson. He concludes thus : "Granting that the chemical processes upon which Dixon, Winchell, and others base their formulas are correct, the geological materials required are water and carbon monoxide or carbon dioxide. There is evidence that these latter substances might come from the calcite of the limestones. Among the contact metamorphic minerals developed between igneous rocks and limestone the most abundant are lime-bearing minerals, two of which, scapolite and diopside, are almost exclusively confined to meta-limestones. Therefore, it seems probable that, if the limestone furnished the lime (CaO) for the silicates, the remaining carbon dioxide (CO_2) furnished the material for the graphite. Of the two derivatives of the calcite, the carbon dioxide would be the more volatile, and therefore the less likely to be caught and crystallized. On account of this, it may be, the graphite is frequently not found actually at the contact, but separated from the igneous rock by lime silicates, which were less volatile. Just what the conditions are that result in the crystallization of the graphite remain to be established."

SHORT NOTICES

Winding Engines.—In the *Colliery Guardian* for June 17, C. D. Mottram commences an article on the graphical dynamics of a winding engine.

Shaft-sinking.—In the *Engineering and Mining Journal* for May 21, E. R. Rice describes the sinking of Van Dyke No. 1 shaft, Miami, Arizona. This was the locale of the champion shaft-sinking exploit referred to in the *Journal* a year ago.

Compressed-air Shovel.—The *Colliery Guardian* for May 27 quotes a paper by M. Clapier read before the Société de l'Industrie Minerale describing an underground shovel operated by compressed air intended for filling coal into cars and filling worked-out stopes.

Air in Mines.—The Institution of Mining Engineers has published the third report of the committee on the control of atmospheric conditions in deep and hot mines, with which is embodied a paper on the subject, written by J. P. Rees.

Bore-hole Survey.—The *Engineering and Mining Journal for* June 4 describes the Wuench "graviscope", an instrument for continuously recording the direction of bore-holes.

Drill Steel.—In *Chemical and Metallurgical Engineering* for June 1, P. A. E. Armstrong describes experimental work in producing hollow drill steel with a decarburized interior surface.

Drill Steel.—The American Institute of Mining and Metallurgical Engineers has published the following papers on drill steel : Analysis of Some Drill-Steel Tests, by F. B. Foley ; Application of Magnetic Analysis to Rock-Drills, by C. W. Burrows ; Heat Treatment of Rock-Drill Steel, by G. H. Gilman ; What is the Ideal Drill-Steel ? by F. H. Kingdon ; Rock-Drill Steels too Short for Use Reclaimed by Welding, by W. T. Ober.

Zinc Dust and Vapour.—*Chemical and Metallurgical Engineering* for May 25 contains a translation of an article in a Norwegian paper on the nature of zinc dust ; and for May 18 of an article on the condensation of zinc vapour.

Zirconia.—The *Journal* of the Society of Chemical Industry for June 15 contains a brief paper by Dr. W. R. Schoeller on the production and testing of zirconia.

Estimation of Arsenic. — The *Chemical Trades Journal* for June 25 reprints a paper read by R. Leitch Morris before the British Pharmaceutical Conference on the volumetric determination of arsenic acid.

Philippine Mining.—In the *Engineering and Mining Journal* for June 4, C. M. Eye writes on mining progress in the Philippine Islands.

Chuquicamata Copper.—In the *Mining and Scientific Press* for June 4, A. W. Allen commences an article on the Chuquicamata copper enterprise in Chile.

Drying Problems.—The *Journal of Industrial and Engineering Chemistry* for May contains a number of papers dealing with various problems connected with the commercial drying of materials.

Alaska Juneau.—In the *Mining and Scientific Press* for May 7, V. C. Clauson gives the history of the Alaska Juneau gold-mining enterprise, and an account of the concentration and metallurgical plant.

Spitsbergen.—The *Iron and Coal Trades Review* for May 27 quotes a description from the Dutch Official Economic Intelligence, of the coal concessions acquired by a Dutch company from the Isefjord Kulkompani of Christiania. The property is on Ice Fiord, to the east of Green Harbour.

Coal in Yugoslavia.—The *Iron and Coal Trades Review* for June 17 contains an article by D. A. Wray on the coal resources of Jugoslavia, the new kingdom of the Serbs, Croats, and Slovenes.

Geology of China.—The *Geological Magazine* for June commences the publication of a paper entitled "An Outline of Chinese Geology", by J. S. Lee, lecturer on Paleontology in the University of Peking.

Felspars.—The *Journal of Geology* for May is devoted entirely to Part I of "The Mineralography of the Felspars", by H. L. Alling.

D. W. Brunton.—The *Mining and Scientific Press* for May 28 publishes an interview with D. W. Brunton by T. A. Rickard.

RECENT PATENTS PUBLISHED

☞ *A copy of the specification of any of the patents mentioned in this column can be obtained by sending 1s. to the Patent Office, Southampton Buildings, Chancery Lane, London, W.C. 2, with a note of the number and year of the patent.*

19,015 of 1919 (163,348). W. J. Nüranen, Helsingfors, and A. Hibbert, Bexhill. Method of separating metals, such as copper and iron in sulphide ores, by roasting to oxide and exposing the mixture to the preferential treatment of a gaseous acid radicle.

19,028 of 1919 (162,682). W. J. Browning, Rio Tinto. An industrial process for the extraction of metals from solutions or for the separation of metals, consisting in precipitating in the form of a sulphide or sulphides one or more metals present in solution by reaction with elemental sulphur and sulphuretted hydrogen produced by burning or calcining or distilling a sulphur-bearing mineral or minerals, such as pyrites or cupriferous pyrites, in the presence of steam additional to that which may arise from the moisture in the material or atmospheric air used, and then passing the residual gas through an incandescent carbonaceous zone while regulating the supply of oxygen and maintaining the optimum temperature of the carbonaceous matter.

19,581 of 1919 (162,307). W. H. Dorman & Co., M. L. Bramson, J. Hanson, and R. G. Hanson, Stafford. Improvements in the construction of wave-transmission rock-drills.

773 and 26,939 of 1920 (163,080) and 6,429 of 1921 (163,659). J. M. Holman and A. T. Holman, Camborne. In air-feed rock-drills, automatic means whereby the drill is rotated without impeding the forward feed.

2,580 of 1920 (138,348). Rare Metals Reduction Co., Baltimore. Method of producing ferro-zirconium.

3,181 of 1920 (131,622). T. A. Eklund, Stockholm. Method of recovering tin from tin ashes and waste tinplate.

3,256, 7,470, and 22,687 of 1920 (162,775). C. J. Williams, London. Improved methods of adjustment for table concentrators.

4,067 of 1920 (163,423). A. J. Dubois, Sarrebruck. Means for loading and unloading mine cages having several decks.

4,983 of 1920 (163,474). O. Reynard, Bradford, and E. Edser, London. Rust-prevention composition for protecting metallic surfaces. The following are claims 1 and 3: (1) A method of preparing a composition for the protection of surfaces, in which anhydrous wool-fat, substantially free from free fatty acid is mixed with a solvent free from water, which will have no injurious effect on the surface and which consists of a non-imflammable volatile liquid, such as trichlorethylene or carbon tetrachloride (or contains sufficient thereof to render the solvent non-imflammable). (3) A process according to Claim 1 of preparing a protective composition in which any crude substance which contains wool-fat and also contains fatty acids, is treated with an oxide, hydroxide, or a suitable salt of a metal which will combine with the free fatty acid to form a metallic soap, preferably a soap insoluble in water, and the product, after evaporating off any water present, is treated with a non-imflammable volatile solvent such as trichlorethylene or carbon tetrachloride or a solvent containing sufficient thereof to render the liquid non-imflammable.

5,228 of 1920 (139,220). J. E. Kennedy, New York. Improvements in jaw-type rock-breakers.

7,027 of 1920 (163,170). Traylor Engineering and Manufacturing Co., Allentown, Pennsylvania. Improvements in gyratory crushers.

7,645 of 1920 (162,486). T. G. Nyborg, Hexham, and M. F. Higgins, Sheffield. Improvements in hand hammer-drills.

8,468 of 1920 (140,775). G. Grondal, Djursholm, Sweden. Slime separating machine.

11,934 of 1920 (155,792). Electrolytic Zinc Co., of Australia, Ltd., Melbourne. In the recovery of zinc by electrolysis, in which lead anodes and aluminium cathodes are used, the removal of chlorine from a zinc-bearing solution prior to electrolysis by adding a soluble silver salt, thereby preventing the corrosion of the electrodes.

13,579 of 1920 (163,210). R. H. McKee, New York. Method of producing zinc oxide and hydrogen by bringing zinc vapour into contact with steam.

17,392 of 1920 (145,710). Fried. Krupp, Essen, Germany. Improvement in the inventor's method of producing low-carbon ferro-chrome.

18,346 of 1920 (146,372). Anschutz & Co., Kiel. Gyroscopic compasses suitable for surveying purposes.

18,964 of 1920 (147,020). Manufactures de Produits Chimiques du Nord, Paris. Deposition of dust from the gases of ore-roasting furnaces by means of hanging chains.

18,967 of 1920 (161,103). Ore Roasting Development Co., Philadelphia. Multiple hearth ore roasting furnace.

19,668 of 1920 (147,686). V. Antoine, Belgium. Improvement in disc crushers and grinders.

20,131 of 1920 (148,210). R. von Zelewski, Hennef, Germany. Improvements in vertical retorts used in the distillation of zinc.

24,280 of 1920 (150,997). H. W. Hardinge, New York. In conical mills fitting a conical hood to the discharge end and revolving with it, the duty of the hood being to arrest the particles that are too big and to return them to the body of the mill.

NEW BOOKS, PAMPHLETS, Etc.

[illegible] can be obtained [illegible] *The Mining Magazine*, [illegible] Wall, E.C. 2.

Salt: Asbestos; Mica: Molybdenite; Platinum: Nickel: Graphite: Manganese. By B. DUNSTAN, Chief Government Geologist for Queensland. These little pamphlets are reprints, revised, of articles that have appeared in the *Queensland Government Mining Journal* during the last year or two. Attention has been drawn to these articles on several occasions in our pages, and some have been quoted in connexion with the information given relating to the Australian deposits.

Text-book of Inorganic Chemistry, Vol. IX, Part 2. Iron and its Compounds. By DR. J. NEWTON FRIEND. Cloth, octavo, 270 pages, illustrated. Price 18s. London: Charles Griffin & Co., Ltd.

Metallography. Part II. The Metals and Common Alloys. By SAMUEL L. HOYT. Cloth, octavo, 470 pages, illustrated. Price 28s. net. New York and London: McGraw-Hill Publishing Co., Ltd.

COMPANY REPORTS

Robinson Deep.—This company belongs to the Consolidated Gold Fields group, and works a deep-level property in the Central Rand. The Booysens property on the dip was acquired more recently, and a new vertical shaft, the "Chris", was sunk. The operations have not been profitable, and the company is saddled with special "A" shares, entitling the holders to large cumulative preferential dividends, which are in arrears, and there is also a loan of £300,000 advanced by the Gold Fields and Central Mining. The report for 1920 shows that 625,150 tons of ore was raised and sent to the mill, where 196,474 oz. of gold was extracted, being 6·29 dwt. per ton. The receipts from the sale of gold were £1,100,693, of which £277,139 represented premium. The working cost was £912,040, and the working profit £188,652. Interest, taxes, etc., absorbed £60,634, and £76,471 was allocated to capital account for shaft-sinking. The holders of "A" shares received £50,000. The revenue per ton was 35s. 3d., and the working cost 29s. 2d. It will be seen that but for the premium a considerable loss would have been made. The ore reserve is estimated at 1,597,000 tons, averaging 6·97 dwt. per ton, the total being much the same as the year before, while the content is 0·38 dwt. higher. In order to develop the deepest ground, it is proposed to sink an auxiliary vertical shaft, at the cost of a quarter of a million pounds.

Planet-Arcturus Gold Mines. — This company belongs to the Gold Fields Rhodesian Development group, and owns the Planet, Arcturus, Slate, and other properties. Early operations were not successful. In 1918 the Slate and Arcturus were leased to the parent company, which advanced working capital on loan. Milling was recommenced in June, 1920. The report for 1920 shows that from that date to the end of the year 30,603 tons of ore was treated for a yield of 12,968 oz., which sold for £73,400, including premium. The working cost was £48,843, leaving a working profit of £24,557, which was applied in reducing the debt to the lessees. The balance of expenditure incurred by the lessees, with accrued interest, amounted on December 31 to £159,657. The main shaft was sunk to water-level at 335 ft. The small amount of development work done has given generally satisfactory results.

Tronoh Mines.—This company has been working alluvial tin properties in Perak, Federated Malay States, since 1901, and has been a large and important producer. The best parts of the properties have been worked out, and recent policy has been to build dredges for the treatment of the poorer ground and tailings, and to let ground on tribute. The report for the year 1920 shows that there has been a further fall in the value of the ground treated. Two dredges were at work and another is in course of erection on the spot. No. 3 mine was worked by pump-dredge. By far the largest proportion of the output was done by tribute. The exact returns were: 51 tons of tin concentrate from No. 3 mine, 43 tons from 239,491 cu. yd. No. 1 dredge, 272 tons from 819,091 cu. yd. No. 2 dredge, and 759 tons from tributers, total 1,125 tons. The accounts show an income of £218,372, and a net profit of £21,463, out of which £20,000 has been distributed as dividend, being at the rate of 10%.

Lahat Mines. — This company belongs to the Tronoh group, and has operated alluvial tin properties in Perak, Federated Malay States, since 1906. The report for 1920 shows that the output of tin concentrate has been increased by the adoption of a drifting system at one of the properties, by means of which a rich lead is followed cheaply. The total output was 533 tons, as compared with 465 tons in 1919. At the underground workings 27,670 cu. yd. was raised and 333 tons of tin concentrate extracted from it, the yield being 28 lb. per cu. yd. The accounts show an income of £101,144, and a net profit of £15,173, out of which £12,000 has been paid as dividends, being at the rate of 10%.

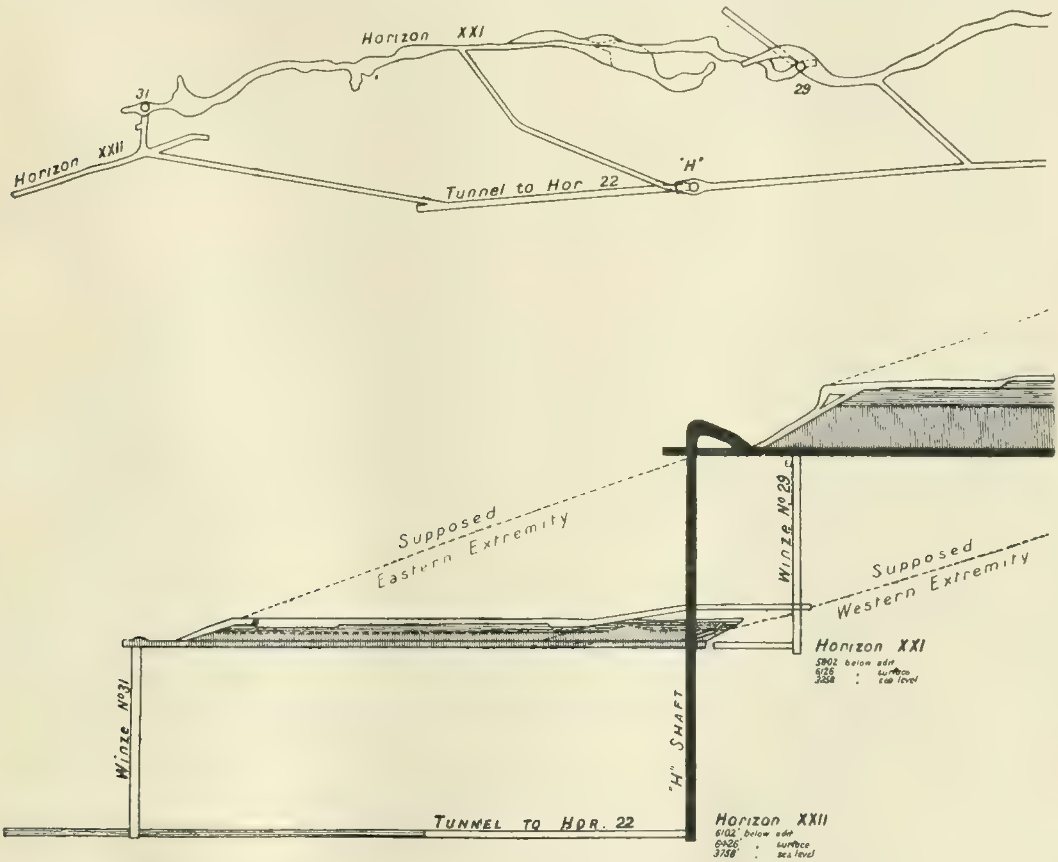
Sungei Besi Mines.—This company belongs to the Tronoh group, and was formed in 1909 to work alluvial tin properties in the State of Selangor, Federated Malay States. The report for 1920 shows that 197,706 cu. yd. yielded 363 tons of tin concentrate, selling for £65,653. Additional land is being acquired to the north, where boring is now in hand. The company has during the past year worked the Kepong property, where 121 tons of tin concentrate was extracted from 230,000 cu. yd. of ground sluiced; at the present price of tin, however, the operations are not profitable. The accounts show receipts £83,815, and a net profit of £17,615, out of which £16,711 has been distributed as dividends, being at the rate of 15%.

Ex-Lands Nigeria.—This company was formed in 1912 to work alluvial tin properties in the southern part of the Bauchi Plateau, Nigeria. The report for the year 1920 shows that 382 tons of tin concentrate was produced, as compared with 360 tons in 1919, and 340 tons in 1918. A pumping plant was recently supplied in order that the rate of extraction might be increased, but owing to general conditions and to the high cost of wood fuel, its use is postponed for a time. At the end of 1919 it was estimated that the company's ground would yield 2,000 tons of tin concentrate. The accounts show a profit of £14,130, of which £8,343 was placed to reserve for income tax, while £6,745 was distributed as dividend, being at the rate of 5%.

Le Roi No. 2.—This company was formed in 1900 by the late Whitaker Wright to work a group of gold-copper mines at Rossland, British Columbia. For the last eighteen years operations have been

conducted under the direction of Alexander Hill and Stewart. The report for 1920 shows that 16,422 tons of ore was shipped to the smelters, averaging 0·878% copper, 12·4 dwt. gold, and 0·71 oz. silver, the gross value of which was $271,742, or $16·55 per ton. The total smelting charges were $122,126, or $7·43 per ton. The loss for the year was £12,181. The work was conducted under exceptional difficulties, owing to the high costs of material, labour, and to the inability of the smelters to handle and pay for the ore promptly. It has been necessary, therefore, to suspend mining for the present. No ore has been sent to the concentration plant recently, but as there has been a considerable increase in fine ore that cannot be hand-sorted, it has been decided to introduce a Minerals Separation plant.

St. John del Rey. — The nintieth annual report of this company, which works the Morro Velho gold mine in Brazil, shows that the output was restricted chiefly owing to scarcity of labour, caused by the unpleasantly hot conditions in the deepest levels. Toward the end of the year the cooling plant came into operation, and the cause of dissatisfaction being removed, more men have been available since. The ore raised and treated was 146,800 long tons, as compared with a normal 180,000 tons. The yield of gold was 98,311 oz., worth £418,210 at par, and the sale of silver brought an income of £4,888. The premium received on the sale of gold was £126,811, so that the total revenue was £549,914, or 57s. 8d. per ton. The working cost in Brazil was £352,097, or 47s. 11d. per ton. The net profit was £167,749, of which three-quarters represented the premium on gold. The sum of £85,000 was transferred to capital works account. The usual 10% was paid on the £100,000 preference shares, and 10% was paid on the £546,265 ordinary shares. The chief development work during the year has been the driving of the tunnel at horizon 22, and the sinking of winze 31 from horizon 21 to horizon 22. This was extremely difficult work, owing to the rock temperature being 117° F. When once the connexion was made conditions improved, and as already stated the cooling apparatus further relieved the situation. Under these circumstances it was not possible to maintain the reserve fully nor to keep the normal number of working faces going. The reserve is estimated at 1,228,000 tons, or about 6½ years' supply; though as part of the lode between horizons 21 and 22 has not been fully explored, Mr. Chalmers considers it prudent to reckon the actually proved ore at 827,000 tons, equal to 4½ years' supply. Further reference to this report is made in the Editorial columns.



Plan and Section of Lowest Workings at St. John del Rey.

Buena Tierra.—This company belongs to the Esperanza group, and operates a silver-lead property in Chihuahua, Mexico. Last year additional capital was raised in order to extend the scale of development. The report for 1920 shows that 6,927 tons of oxidized ore was shipped, averaging [illegible] lead and 8·6 oz. silver per ton, for which the smelters paid $63,048, or $9·10 per ton. The accounts show a loss of [illegible]31,619 for the year. Owing to the low prices of lead and silver, the high cost of development work, and the excessive railway rates and smelter charges, it was decided to suspend operations on June 30 of this year.

Esperanza.—This company has worked the Esperanza gold mine at El Oro, Mexico, since 1903. Large profits were made for some years, but operations are now confined chiefly to the treatment of low-grade ore, old fillings, and tailings. The report for 1920 shows that 273,120 tons of ore was sent to the mill, where gold and silver realizing $1,370,555 was extracted. The loss at the mine was $406,491, after allowing for depreciation of plant and depletion of the mine. The reserve of ore and filling is estimated at 117,684 tons, together with 750,000 tons of lower grade material that might show a profit in normal times. As has been recorded from time to time recently, development is being actively continued and has occasionally disclosed high-grade ore. The company has an option on the Union en Cuale property, where active development has been done. Owing, however, to the unsatisfactory state of the metal market, it has been deemed best to suspend this work, though the option is being continued.

Esperanza Copper and Sulphur.—This company was formed in 1906 to work a group of pyrites mines in the south of Spain. Shipments have been maintained fairly steadily, and operations were not disturbed by the war to the same extent as those at other mines in the district. The only year when there was serious restriction was 1919, during which the shipments were only one-third of the normal. The report for 1920 shows that the output of pyrites was 71,176 tons, and that 85 tons of copper precipitate was produced. The dispatches of pyrites from the mine to the port of Huelva were 61,719 tons, and the shipments thence 82,970 tons. If it had not been for a railway strike, which occupied ten weeks, the normal shipments of 100,000 tons a year would have been reached. The reserve of developed ore is estimated at 835,000 tons. The accounts show a profit of £14,598, and £17,500, less income tax, has been distributed, the rate being 5%. The company also has a controlling interest in the Cyprus Sulphur & Copper Co., which owns low-grade deposits, the treatment of which is still under consideration.

Great Boulder Proprietary.—This company was formed in London in 1894 to acquire gold mining claims at Kalgoorlie, West Australia, and for twenty-five years handsome dividends have been paid. During the last year or two the output and profits have been smaller, owing to shortness and indifference of labour, high costs, and the arrival of the workings at the bottom limits of the orebodies. The report for 1920 shows that 100,756 long tons of ore, averaging 14·26 dwt. per ton, was raised and treated, yielding gold worth £305,212 at par, to which must be added £123,500 received as premium. The total revenue was £428,713; the working cost was £215,712; allowance for depreciation £25,000, and taxes £47,468. The shareholders received £131,250, the dividends amounting to 75%. Richard Hamilton, the manager, estimates the reserve at 245,187 tons, averaging 14·75 dwt. per ton, as compared with 325,314 tons averaging 14·56 dwt. the year before, and 345,719 tons averaging 14·49 dwt. at the end of 1918. [illegible] new properties, the option on the Maher at Comet Vale has been abandoned, but the O.K. at Norseman is giving good results. The continual rise of costs at Great Boulder is shown by the fact that the cost per ton in 1920 was 41s. 9d., as compared with 35s. 8d. in 1919, and 32s. 6d. in 1918.

Zinc Corporation.—This company was formed in 1905 to treat zinc tailing at Broken Hill by the flotation process. In 1911 the South Blocks mine at Broken Hill was acquired, and the company then became a lead producer as well. The present report covers the year 1920. During this time the mine and plant were largely idle owing to the strike, and it was not until November that mining was resumed, while concentration was not started until the next month. Until the end of the year the lead concentrator treated 6,908 tons of ore, averaging 17% lead, 10·4% zinc, and 2·8 oz. silver per ton, and produced 1,620 tons of lead concentrate, averaging 63·8% lead, 7·1% zinc, and 9·2 oz. silver; together with 2,212 tons of zinc tailing, averaging 18·5% zinc, 4·2% lead, and 1·6 oz. silver. At the zinc concentrator 28,110 tons of tailing and slime was treated, of which 24,920 tons came from the old dump, averaging 16·4% zinc, 4·1% lead, and 5·1 oz. silver, and produced 7,670 tons of zinc concentrate, averaging 48·2% zinc, 6·9% lead, and 8·7 oz. silver, together with 542 tons of lead concentrate, averaging 54·3% lead, 17·9% zinc, and 24·5 oz. silver. Since the end of the year it has been found impossible, with the high wages and the low price of lead, to continue the production of lead concentrates; moreover, there was a fire at Port Pirie smelting works, as already recorded. The only operation conducted at present is that at the zinc concentrator, and the zinc concentrate produced is sold to the Government under the contract made shortly after the outbreak of war. The ore reserve in the mine is estimated at 2,115,700 tons, averaging 14·6% lead, 9·4% zinc, and 2·6 oz. silver. There is also 664,633 tons of dump material to treat, and 31,472 tons of zinc slime. The accounts show an income of £109,132 from the sale of concentrates, and a profit of £31,910, out of which £24,569 was distributed as preferential dividend for the first half of 1920.

Amalgamated Zinc (De Bavay's).—This company treats zinc tailing at Broken Hill, and until recently was mainly occupied with the treatment of this material coming from the North and South mines. At present old dump material occupies chief place. The company has a large holding in Electrolytic Zinc of Australasia, and also conducts experimental work in other directions. The report for the half-year to December 31 last shows that work was resumed in the middle of November on the termination of the strike, and during the six weeks to the end of the year 14,852 tons of material was treated for a yield of 3,403 tons of zinc concentrate, averaging 47·7% zinc, 6·7% lead, and 13·4 oz. silver per ton, together with 32 tons of lead slime concentrate, averaging 48·6% lead, 15·7% zinc, and 76·6 oz. silver. The accounts show a loss of £16,651 on the half year.

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EDITORIAL

ON July 25 the Institution of Mining and Metallurgy moved to its new premises in City Road. The house is commodious and well arranged, and though its surroundings are not just what the council would have chosen if office accommodation in London had not been so restricted, it can at least be said that the continuous omnibus and tram services to the City nullify the feared isolation of the new home. The Institution of Mining Engineers has also moved to City Road, and Mr. C. McDermid has assumed the secretaryship of both societies. We give herewith a photographic view of the building, and in a later issue we hope to publish a detailed description.

THE INSTITUTION OF MINING AND METALLURGY'S NEW HOME.

ELSEWHERE in this issue Mr. T. Skewes Saunders describes the mines of the Dos Estrellas Company at El Oro, Mexico. This mine has given big profits to Mexican and French owners from extremely rich ores, and of late years profits have been made by the scientific treatment of the remaining ores of lower grade. Details of the mine have never been published, so that the complete history of the El Oro district has never been available. The present article may serve to fill in some of the gaps. In another part of this issue we reprint a paper by Mr. Horace V. Winchell on the geology of Pachuca and El Oro. His advice as regards El Oro is timely, and should be appreciated by those who are in favour of further exploration.

A BILL before United States Congress relates to the establishment of a Department of Mines, assimilating old offices and creating new ones. It is proposed that the present Bureau of Mines should be converted into a "Bureau" of Mineral Technology, and the Geological Survey into a "Bureau" of Mining and Applied Geology. There would also be a "Bureau" of Mineral Markets, and a "Bureau" of Public Mineral Domain. In addition there would be a "Division" of Mineral Statistics, a "Division" of Publications, and a "Division" of Accounting and Disbursing. By those in this country who are beginning to hate the words "Bureau," "Departments," and "Divisions," this announcement is not received with enthusiasm.

NOT long ago a note was published in these columns relating to the gyrostatic compass, and to the possibility of its application to mine surveying as a substitute for the magnetic compass in indicating the true north. Surveyors in

this country were aware at the time that an instrument embodying this idea had been developed in Germany, but no one could give details. Attention may therefore be drawn to the abstract of the patent issued to Anschutz & Co., appearing elsewhere in this issue. The specification and drawing give an idea of the principle of the instrument, but we hope in a future issue to publish further information supplied by the makers.

THE Cornish Chamber of Mines Year-book for 1921, edited by Mr. Harold E. Fern, is a reflex of the contracted state of local mining, but in the comparatively few pages a great deal of valuable history and statistical information is given. These records are valuable both currently and for permanent reference. The contents of the volume include the report of the Council for the year 1920, details of the various metal-mining companies operating in Cornwall, and statistical tables of production. A valuable feature of the volume is a table giving analyses of the working costs during 1920 at five of the leading tin mines; namely, East Pool, Dolcoath, South Crofty, Tincroft, and Geevor. These figures explain why costs have been advancing so seriously during the last few years.

WHETHER gold is to go back to its original value, or whether we are to continue to send the metal to the United States and live on paper in this country, is the chief financial problem of the day. The only orthodox way of bringing gold back to its par value is to cut wages and public expenditure in this country. In this issue we publish an article by Mr. S. J. Speak, who demonstrates the inability of the Government and the financial authorities in the City to effect this desirable reinstatement of the basic principle. Mr. Speak's opinion is that the appreciation of gold should be regularized, and that its price should be put to six guineas per ounce. In this way the relation of prices to values would be more easily revised without the working-classes being provided with a reason for strikes. The relation of gold to official currency is one of those difficult problems that a layman, even a professor of political economy, cannot always grasp, but there are cases, allied to mathematical "limits," which are easily comprehensible. For instance, the great discoveries of gold in Australia and California had both a sudden and an ultimate influence on currency and wages, and gold as such suffered a depreciation; while, on the other hand, the uncontrolled issue of paper money by the Confederates and by various Governments in South America caused nominal prices to go up indefinitely. In the depreciation of money by the State gold is not in the hands of the public, so they reap no benefit against the fall in its purchasing value, the matter being entirely in the control of the exchange bankers. The fact is that the public have no control of the price of gold, or even of diamonds, and the disposal of either is in the hands of the rings. Mr. Speak's article gives, under the circumstances, an intelligible solution of a much-debated question.

LAST month we recorded that Mr. Bradley Stoughton had resigned the secretaryship of the American Institute of Mining and Metallurgical Engineers. Since then it has been announced that he is succeeded by Mr. F. F. Sharpless. Mr. Sharpless will be known to many people in London, for he was at one time an adviser to the Consolidated Mines Selection Company, and in this capacity he visited West Africa. He has been professionally associated with Mr. Horace Vaughan Winchell, and with other influential men who devote much time and thought to the interests of the Institute, and he has been secretary of the Mining and Metallurgical Society of America. So he is well known to mining engineers and experienced in society administration. But while thus prognostigating success for his tenure of office, we still cannot help expressing our inability to understand why Mr. Stoughton should have felt it incumbent on him to resign. The secretaryship of the Institute has not provided the only worry to the council recently, for the publication of the monthly paper *Mining and Metallurgy* is also the cause of grave concern, and the multiplicity of unwieldy committees is once more being adversely criticized in various quarters. As regards the monthly paper, we notice that the *Engineering and Mining Journal* expresses its disapproval of it, both from the point of view of policy and in relation to its intrinsic merits. With sly subtle humour the writer shows how little original matter is found in its pages, and how it fails to serve the requirements of the mining engineer and metallurgist. The humour is so subtle that we are unable to say whether the fact of *Mining and Metallurgy* having

somewhat of the flavour of THE MINING MAGAZINE but not so compact" is intended as a compliment to both, either, or neither of the monthlies mentioned ; probably neither. But seriously, the *Journal* is to be congratulated on the stand it has taken, for its advice and comment will go a long way. It is to be hoped that the Institute will revert to its *Bulletin*, and at the same time go back to its old policy of quality rather than quantity in the matter of papers published. We note in the American papers some reference to a proposal to amalgamate *Mining and Metallurgy* with the organ of the American Mining Congress. Surely such a step would put the Institute still further off the mark, and would be regarded with dismay by mining engineers outside the United States.

Rhodesia Broken Hill

In these days of depression in the metal markets it is remarkable that a lead mine in the centre of Africa should be making profits and paying dividends. But this is what, in spite of so many disadvantageous circumstances, the Rhodesia Broken Hill Development Company has been able to do. During 1920 the yield of lead was 14,602 tons, obtained by smelting 42,806 tons of ore ; the net profit, after allowance for depreciation, was £89,949, out of which £35,000 was paid as dividend, at the rate of 10%, the remainder being kept in hand until income tax and excess profits duty are settled. The deposit belonging to this company, situated in Northern Rhodesia, is one of the most interesting of all those controlled in London, and we were glad to be able to publish a detailed account of it in October, 1919. In glancing briefly at the report of current progress, it is not necessary to review past history or to give a general description of the property, for the article in question contains all this information. During the last year or two further geological investigations have been made, and it is now considered certain that the various outcrops are parts of two lodes about 1,000 yards apart. One of these lodes outcrops at kopjes Nos. 1, 3, and 4, and contains more lead than zinc ; while the other passes through kopje No. 2 and consists essentially of zinc ore. There are a number of other outcrops, of minor importance at present, which have not yet been explored in depth. The further development of the ore, and also the theory of the geology and the origin and continuance of the ore deposits, depend largely on the water question. As recorded two years ago the surface-workings are drowned with water, and it was an open question whether pumping would be effective at anything like a commercial cost, and consequently whether it would be possible to sink shafts. The directors decided to provide powerful pumps, which were eventually delivered after great delay, and at enhanced prices. They also called to their service the Francois cementation process, by means of which shaft-sinking became possible immediately, and should continue to be independent of the water. The No. 1 shaft has been sunk to 173 ft., and a level is being opened at 150 ft. By means of these workings, it will be possible to follow the indications provided by the bore-holes. In connexion with the water, which has given so much trouble, and has also worried the geologists, it has been shown recently that the water-level is now much higher than it used to be, and that a drainage channel 300 ft. deeper than the present water-level was in action at no distant date. Thus the existence of oxidized ores below the present water-level is explained, coupled with a certainty of the permanence of sulphide ores below the portions already proved by bore-hole. A hope is also provided for an eventual clearance of the water from an apparently waterlogged area. Another interesting geological point relates to the occurrence of vanadium minerals. During 1920 a substantial income was derived from the sale of these ores, and arrangements are being made for their further exploitation. At the present time the proved vanadium reserves consist of 3,750 tons, averaging 7 to 13%, and 6,000 tons averaging $3\frac{1}{2}$%. Experimental work is in hand for the concentration of these lower-grade ores, and eventually it is believed that vanadium will be an important factor in the success of the property. As regards the zinc contents of the ores, it is only necessary here to say that electrolytic plant is on the spot, and that results will be available later. In concluding this brief notice, it is right that personal credit should be given. Mr. Edmund Davis, as chairman and managing director, provides the business ability, Messrs. Hooper, Speak & Co. are the consulting engineers, Mr. Ross Macartney is the manager at the mine, and Mr. F. P. Mennell has been engaged in geological studies.

Cornish Conditions

During the last few months we have published no Camborne letter in our news columns, for our local correspondent bluntly says there is nothing to write about: Cornish mining is dead, hopes of resuscitation are remote, and to write of the terrible position and the distress would be unkind to the sufferers. It is to his credit that he fought for the cause of Cornwall during the threatening days, canvassed the practical sympathy of those in power, and foretold the results of the Government's policy of neglect and drift. It is no wonder that he is disgusted with journalism which has proved so ineffective, and has laid aside his pen for the time. But something must be said about Cornish matters, even if it is only with the object of arousing some sympathy for the victims of adverse circumstances. Of the men who are perforce idle, it has to be said that they were never overpaid and that they never upset normal arrangements by making impossible demands. In fact there have been cases where they have suggested a curtailment of pay in order that operations should not cease. Their attitude has been entirely different from that of the coal-miners, who induced the Government to pledge public funds for the maintenance of high wages in a prosperous industry that can pass the extra cost to the consumer. The tin-miner was faced with the higher cost of coal, steel, timber, and explosives, and he was quite unable to pass the extra costs to the buyer of his products, for the metal markets are entirely beyond his control; while, as for assistance from the public purse, this was not granted until wages were not forthcoming. It was always the contention of the MAGAZINE that the mines should be kept working by aid of the public money now distributed as charity and without profit to the giver or the community, though it was fairly clear that the proposition would stand no chance of acceptance. It is too late now to revive an argument in favour of such a course. All that can be done is to help the miner in some practical way and to break the appalling darkness and silence that broods over Cornwall. The out-of-work pay is little enough, and is quite insufficient for keeping life together with decency and respect; but now even this resource is threatened, and the men never know when they will be entirely without means of subsistence. The funds at the disposal of the poor law guardians are already strained to the limit. Voluntary contributions have been liberal, and the Central Relief Committee at Camborne has been able to be of great assistance, but as the days drag by it becomes increasingly difficult to obtain the necessary funds locally. Early this year Mr. Joseph H. Cock, a member of the staff of the Mining School, who was at the time chairman of the Relief Committee, issued an eloquent appeal to Cornishmen abroad to contribute to the funds for the help of distressed folks at the old home. It is gratifying to know that the response was excellent, and that much good was thereby done. Time has since passed and the position in Cornwall is still tense, so we re-echo Mr. Cock's invitation, and trust every Cornishman who reads this article will lose no time in getting into contact with the secretary of the Camborne Relief Committee, the Reverend W. A. Bryant. Before concluding we would mention that many people not conversant with mining conditions recommend the present distressed Cornishmen to emigrate as their fathers and grandfathers did at former periods of mining depression in the old county. Unfortunately it is difficult to follow this advice, for the countries where additional mining labour is wanted are few and far between. Nevertheless if any influential Cornishman abroad can guarantee positions for stranded miners at present in Cornwall his assistance in this direction will be as welcome as a subscription to the funds.

This is the position of things in Cornwall at present. Oh, the pity of it that the sons of an ancient and honourable industry should have to plead for help through no fault of their own!

The Framing of Mining Laws

Reference has been made in these pages on one or two occasions to the excellent work done by the Indian Government in the control of industrial operations. At a time when Indian affairs looked gloomy, and even ugly, a number of sound and experienced servants of the State rallied to its support, and by the exercise of firmness and patience have guided the community to commercial and political safety. Unfortunately the English Press tells us little or nothing of what goes on in the Overseas Dominions, so that the transcendent abilities of Sir Thomas Holland as an administrator are comparatively unknown in this country. The Indian Government has, however, recognized the uses of

publicity, and has made a number of innovations tending to bring its motives and aspirations to the notice of the political and business communities, both locally and in this country. For instance, an Indian Trade Commission has been established at Winchester House, in the City, and many of our readers will have had the advantage of the help and advice of Dr. J. Coggin Brown, who has been found at that office for the last year or so, in connexion with the mineral industries of India and neighbouring countries. More recently the Government has founded the *Journal of Indian Industries and Labour*, with the object of providing a means of contact between the various industrial communities throughout India, and of explaining the underlying principles on which the Government acts. It may be said at once that the Government of India aims at idealism tempered with business acumen. The benefit of the State is the watchword; but, on the one hand, the benefits are not to be entirely controlled by the business man, and, on the other, the State is not to be represented by the blatant agitator or the fluent ignoramus. In fact, it is a combination of the high-mindedness of President Wilson and General Smuts with the mundane philosophy of Cecil Rhodes.

An excellent example of the straightforwardness of the Indian Government is to be found in the May issue of the beforementioned *Journal*, where Sir Thomas Holland writes on the principles governing the grant of mineral concessions in India. Sir Thomas, being alarmed at the apparent simplicity of his exposition of the principles, declares, with his characteristic vein of irony, that "these general considerations are mostly platitudes"; but as all knowledge and mental exercises when clearly expounded may be mistaken by some people for platitudes, we can easily imagine the smile on his face when he wrote or dictated that word. Briefly, the mining laws of India are so framed as to offer sufficient speculative attraction to the capitalist, and at the same time ensure a fair return to the State without undue waste of the natural resources. It is the business of a mining company to make as much profit as possible out of a mineral deposit in the shortest time; this is extravagance from the point of view of the community. On the other hand, the State must see that its mineral resources are utilized for, following their judicious employment, there comes great commercial advantage and prosperity. Yet, seeing that these resources are limited, care must be taken that they are not carelessly or wastefully mined; in other words, complete and gradual extraction is better for the community than rapid profit-making by the mining companies. Sir Thomas puts the case of the miners quite candidly. He points out that, as most mining enterprises are highly speculative, the investor wants the encouragement of generous terms before he will risk capital in an unproved country; that most of the capital is sunk in an irrecoverable form, for the miner cannot sell his shafts and levels in the open market, and he must therefore hope to recover his initial outlay from his profits in a relatively short period; and that unless a miner can now and then reap the benefit of an occasional windfall, he will not be able to write off the losses due to the large number of unlucky ventures inevitable in this class of work. To weigh all these considerations without prejudice or bias is the aspiration of the Indian Government, and, as Sir Thomas says, the expression of these principles looks like a platitude. But how many other countries can point to so clear an exposition of their motives? In other States we see indifference to public or private interests, or an inclination to opportunism, or a participation on the part of the State or its minions in the clash of the markets, in the manœuvres for position, and in the crushing of opponents or rivals, or even a policy which puts business in the way of lawyers and experts.

Sir Thomas Holland, in his article, proceeds to details on one or two debatable points. He gives reasons why the law should be uniform throughout all the Indian States, and he shows why it is necessary to revise the law periodically. He discusses the relation of prospecting licences to mining leases. Here he shows how it is necessary to give liberal terms to the genuine prospector and the obviously earnest investor, and he indicates the necessity for differentiating between the various fields of enterprise. In some cases the surface indications are such as to make it imperative for definite results to be available in a comparatively short time; whereas, in other cases, such as drilling for oil, much longer periods of prospecting should be allowed.

We may be permitted to express the hope that directors will read Sir Thomas Holland's article, for it incidentally gives an excellent

idea of the actual importance of mining relative to other local industries. Most of the companies and their directors are fully aware of their duty to the laws and customs of the various countries, as well as to their own shareholders, but occasionally companies, or groups of companies, come into undesirable and unnecessary conflict with communities and their governors by exaggerating their claims to recognition and by want of capacity to regard affairs in their true perspective. A perusal of this article may act as a corrective.

The Forces of Nature

In this issue we print an article by Mr. J. H. Goodchild, entitled, " Land Growth," which, we readily admit, is not easy to comprehend at the first perusal. The casual reader and even the expert geologist and petrologist may possibly be mystified, as they were with the articles by the author's brother, Mr. W. H. Goodchild, on the origin of igneous ore deposits, which appeared in these pages three years ago. Nevertheless, the author's views will find response in the minds of many students of geology who feel that there is something missing in the theories taught in the textbooks. At the present time the mineral arrangement and the constitution of the earth's surface is ascribed to either igneous action or sedimentation, that is to say, some rocks are held to be the cooling products of a molten magma, while others are the result of meteoric action on existing land surfaces. Mr. Goodchild would add to these influences the chemical reactive energies of the minerals and mineral masses. These chemical forces are, of course, well enough known to geologists, but hitherto argument involving them has been confined to discussions as to the origin of underground ore deposits. Under the latter conditions the potency of solutions to attack, convey, and precipitate are fully recognized, and deductions are facilitated by the fact that material exists concurrently in both the original form and as middle and final products. Few geologists have attempted to apply the same principles to the wider field, and this application is rendered the more difficult because only the current product is visible. This difficulty may be exemplified by reference to the permanence or otherwise of old buildings. The remains of Roman and Egyptian edifices lead people to suppose that the ancients knew better how to build than we do nowadays, they entirely forgetting that the evidence of bad building in the olden days has long since disappeared. Another difficulty in applying this principle in its wide sense is that different substances act at different rates, the least plentiful usually acting the most rapidly. Carbon, phosphorus, and potassium go through cycles of adventures, while silica and most of the silicates are slow of change and reaction. The only constituents of the earth's surface that are plentiful, and at the same time show visible and calculable changes, are carbonate of lime and the iron compounds. Thus Mr. Goodchild would recommend a close comparative study of the iron ores of the world from his standpoint, including those in Cumberland, North and South Spain, India, Brazil, and Lake Superior. That such a study would meet prodigious obstacles cannot be denied, for direct evidence would be scarce, and often almost unrecognizable, and until some evidence of this growth of land is obtainable many scientists and practical men may as likely as not refuse to believe in its importance. For ourselves we keep a receptive mind ready to consider any proposal put forward by a serious and competent student of nature. These chemical forces acting on a large scale as outlined by Mr. Goodchild would provide explanations for many phenomena which are at present obscure, and they would afford alternative explanations for others. For instance, banded ironstones and doubtful gneisses would be explained ; the apparently igneous rocks which look like sedimentaries, or vice versa, would be relegated to their proper division ; an explanation would be provided of the absence of metamorphism at the contact of certain supposed igneous intrusions ; it would no longer be necessary to attribute schistosity or slatey cleavage to enormous pressures, nor contortions of rocks to the folding or crumpling of plane deposits. Sulphur would cease to be essentially a hypabyssal element, and pyrites would be usually formed by the action of iron compounds on organic substances. The current principles of petrology may appear to stand in the way of some of the foregoing applications, particularly where a doubt is implied of the igneous origin of certain rocks ; but that remains to be seen. However, we are travelling a little too far in advance. These prospective explanations are merely given as an indication of incentives to investigation on Mr. Goodchild's lines.

REVIEW OF MINING

Introductory. Though coal mining has been resumed for over a month in this country general trading is still stagnant and the prices of industrial metals continue at a low ebb. As for gold, the United States Exchange has dropped again, and the premium has correspondingly risen.

Transvaal.—The labour question has been to the fore this month, and definite proposals were made by the Chamber of Mines for a cut in wages. The men have agreed to a standard of wages based on the cost of living, and this involves a reduction of 1s. 6d. per shift immediately. It is felt, however, that more than a cut is wanted, and that a weeding out of disaffected incompetents would do much more good.

Further particulars are to hand from South Africa with regard to the stoppage of sinking at No. 2 shaft, West Springs. It is now stated that this shaft had reached a depth of 3,000 ft. without having encountered the Kimberley slates, which were expected at a depth of 2,300 ft. to 2,400 ft. A big transverse fault-plane is known to traverse the Springs property, and No. 1 shaft is near this line of disturbance. No doubt this dyke has had a disturbing influence on the country round No. 2 shaft.

About eighteen months ago additional capital was subscribed for the reopening of the Sheba Gold Mining Company's properties at Barberton. Since then much prospecting work has been done. The mine that has responded best is the Zwarzkopje, where 14,603 tons averaging 10·4 dwt. gold per ton has been proved. At the Intombi section the reserve is 20,000 tons, averaging 10 dwt. Further development is to be done before milling is recommenced, and when that happens it is intended to add tube-mills for the purpose of grinding the ore finer.

Rhodesia.—The output of gold in Southern Rhodesia during June was 49,466 oz., as compared with 48,744 oz. in May, and 45,054 oz. in June, 1920. Other returns of output for June were as follows: Silver, 13,243 oz.; coal, 49,425 tons; chrome ore, 5,831 tons; copper, 264 tons; asbestos, 1,993 tons; arsenic, 48 tons; mica, 7 tons.

The Lonely Reef Gold Mining Company reports the ore reserves at June 30 at 197,704 tons, averaging 19·11 dwt. gold per ton, as compared with 202,845 tons averaging 20·8 dwt. at the end of December last.

There appears to be some chance of a deal being effected between the Globe & Phœnix and the Rhodesia Exploration Company (formerly Amalgamated Properties) with regard to the John Bull and other claims round which the celebrated lawsuit centred. The chairman of the latter company has announced that he is in negotiation with a director of the Globe & Phœnix, but whether officially or not is uncertain. The Globe & Phœnix reserves at June 30 were calculated at 89,491 tons averaging 30·39 dwt. gold per ton, as compared with 93,852 tons of similar tenor six months previously.

West Africa.—The Ashanti Goldfields Corporation announces the intersection of the Obuasi lode at the 19th level. Here the lode is 26 ft. wide and averages 19·9 dwt. of gold per ton.

Australia.—The reports of several companies operating at Kalgoorlie are quoted elsewhere in this issue. These companies are now securing full benefit of the gold premium, and are thus able to earn increased profits. But gold premium does not account for all, and in this connexion we may express our pleasure that Mr. J. A. Agnew drew attention to the excellent management of the mines which is also a substantial factor in the present position. Too often most of the directors and all the shareholders omit to give any real credit to the mine managers for the satisfactory results; they even begrudge the few minutes occupied at the end of a meeting when a perfunctory motion of thanks to the staff is introduced, for this item of the agenda unnecessarily cuts into their lunch.

The cabled report of the Hampden Cloncurry Copper Mines for the half-year ended February 28 shows a yield of 1,882 tons of copper, 1,149 oz. gold, and 7,256 oz. silver obtained from the smelting of 36,698 tons of ore, of which 4,065 tons was custom ore and 9,391 tons metalliferous flux. The operations resulted in a loss of £6,694. As already recorded the properties and the smelter are now idle, awaiting a reduction in wages and in the costs of stores.

During the year ended May 29, the ore raised at Mount Morgan totalled 260,062 tons, of which 89,405 tons was sent direct to the smelter. At the concentrator 167,802 tons of ore yielded 60,033 tons of various classes of concentrates. The smelter treated the ore sent direct, together with 19,129 tons of

jig concentrates and 32,667 tons of table and flotation concentrates. The yield of copper was 5,149 tons, and of gold 76,463 oz. It has not been possible to declare a dividend. At present the labour position is uppermost, and the directors are endeavouring to induce the men to adopt some scale of wages that will make it possible to operate without loss. The company is actively developing and equipping a coal mine at Baralaba for a capacity of 500 tons per day. Experiments are in hand for chlorinating the tailings from the concentrators with a view of saving further quantities of gold.

The Governments of Great Britain and Australia continue to refuse information as to the price paid by the former for Australian zinc concentrates. The Board of Trade states that the total sums disbursed for the years ended March 31, 1919, March 31, 1920, and March 31, 1921, were £1,221,859, £490,137, and £151,951 respectively. It is also announced that concentrates totalling 4,972 tons have been sold at an average price of £7 17s. per ton. Presumably this is the sum of the sales all these years. Their deal has not been good business for anybody except some of the producers at Broken Hill, and even these will eventually suffer owing to the large Government stocks standing in the way of a revival in mining.

India.—Champion Reef will be the next Indian mining company to reconstruct with the object of providing funds for further development in depth. Mysore and Nundydroog have already reconstructed, but Ooregum has been able to provide funds for the same purpose out of its rich ore reserves. The directors believe that the ore disclosed in the lowest workings justify deeper development, so a scheme for raising the necessary capital will be submitted to shareholders next month. It may be mentioned that the shaft in Carmichael's section of this mine is over 6,000 ft. deep on the dip.

Burma. — The Burma Corporation announces a reconstitution of the London Committee, which now consists of Sir Henry Strakosch, Sir John Mann, and Messrs. J. A. Agnew, A. Chester Beatty, F. A. Govett, Herbert Guedalla, and J. C. Prinsep. Mr. E. P. Mathewson is to visit the mine and advise on the metallurgical position.

Malaya.—The report of the Federated Malay States Mining Department for 1920 shows that 34,938 tons of tin concentrate was exported; of this amount 22,134 tons came from Perak, 8,851 tons from Selangor, 3,252 tons from Pahang, and 697 tons from Negri Sembilan. It is stated that 64% of the mines were under Chinese management, as compared with 68% in 1919, and 74% in 1913; it would be much more interesting if the relative percentages of output by Chinese-managed companies were given.

Cornwall.—The respective boards of East Pool and South Crofty have not yet been able to find a basis of joint action in connexion with the unwatering of the mines. After the pumps at East Pool main shaft were put out of action by the collapse of ground, pumping was continued at Agar shaft for a time. This pump has since been stopped, but owing to the dry season the water is not rising rapidly. The board of East Pool have now in consideration a scheme for sinking a new shaft, at a point situated to the north-east in the Tolgus section.

Shetland Isles. — For the benefit of numerous readers who have sent inquiries relative to a paragraph in the last issue we record herewith the formation of a company called the Sand Lodge Mine, Ltd., with a capital of £100,000, to acquire property from the Shetland Exploration Syndicate, in Sandwick and Cunningsburgh, on the Mainland of Shetland. The new company is housed with Murrietta & Co., Ltd., 19, Great Winchester Street, E.C., and Dr. J. R. Garbe is the consulting engineer. We await the publication of a report on the property by a mining engineer of recognized position.

Canada.—The Kirkland Lake Proprietary Company is taking steps to increase the scale of development on its properties, the Tough-Oakes, Burnside, and Sylvanite. Mr. S. C. Thomson, of New York, who was at one time consulting engineer to Messrs. S. Neumann & Co., in South Africa, has been appointed consulting engineer to the Kirkland Lake Proprietary, and it is also understood that Mr. W. H. Goodchild is to be sent out to make a geological study of the properties. In this connexion it is of interest to read what Mr. Reginald E. Hore has to say in the *Canadian Mining Journal* with regard to the prospects of the Kirkland Lake district. He strongly recommends the resumption of surface prospecting on a systematic scale by stripping the overburden. He is of opinion that continuity of the deposits in depth may be expected and that liberal expenditure on development and underground prospecting is warranted. He

specifically mentions the Lough Oakes, where he recommends a search for the continuation of the ore-body which was cut off by faults both laterally and in depth.

United States.—The proposal to place an import duty of 35 cents per barrel on crude and one of 25 cents on fuel oil has not been received with approval by the Government. The House of Representatives struck the clause out of the Tariff Bill, while President Harding has issued a message declaring that such an action would be entirely opposed to the present policy, which seeks an open door for the United States in all the oil-fields of the world.

Mexico.—The politics of the oil position is intimately interwoven with United States interests and the battle is between the American oil controllers and the Mexican Government. The American producers who recently suspended operations as a protest against the increased export tax have decided to resume operations.

Alarming reports were spread last month with regard to a fire in the Amatlan oilfield. Fortunately these reports proved to be greatly exaggerated, and it appears that only four wells were involved. The properties of the Mexican Eagle company were not damaged in any way. In fact, the engineers of that company did much to bring the fire under control and prevent it spreading.

The following figures for the output of base metals and minerals in Mexico during 1920 are given by the Financial Agent in New York of the Mexican Government :—

	Metric Tons.
Lead	82,517
Copper	49,192
Zinc	15,650
Mercury	75
Manganese	1,137
Antimony	622
Tungsten	40
Molybdenum	4
Arsenic	2,091
Graphite	3,222

There is nothing to indicate whether these figures relate to metal extracted, metallic contents, or ores.

Venezuela.—The reports now issued as to prospects at the South American Copper Syndicate's mine at Aroa are distinctly encouraging. The diamond-drill campaign has proved the existence of a new ore-body of obvious importance, and this method of exploration has been fully demonstrated to be the right one for ores of this sort, that is to say, copper sulphide deposits in limestone. The new smelting plant is ready to start whenever the power plant is completed.

Colombia.—At the meetings of the Nechi and Oroville Dredging companies, Mr. J. A. Agnew gave some particulars of the method of realizing the gold produced. This information supplements the remarks on statistical returns published in the July issue of the MAGAZINE. The gold produced by the Nechi and Pato companies is shipped to New York for realization, and the mining profits transmitted from New York to London receive the benefit of the gold premium. For some time the companies were not allowed to export their gold from Colombia, and even now it is not possible to ship it as coin or bars. The companies, however, found that it was possible to ship it as sponge, and they go to the inconvenience of putting it in this form. It will be seen from this explanation that the periodical outputs are given in United States currency and that the benefit of the premium comes in the remittance of profits from New York to London.

Spain.—Some perturbation has been caused among the English and other foreign mining companies operating in Spain by the issue of a royal decree preventing the holding of mining property by any companies other than those of local domicile, which must have both chairman and managing director of Spanish birth. Apparently this decree affects only new ventures or expansions of operations by present companies, but this point is not clear. In any case there is some doubt whether such an important change could be made by royal decree.

The Pena Copper Company raised 82,751 tons of ore during the year 1920, of which 43,161 tons went to the leaching floors. The precipitate obtained contained 516 tons of fine copper. The shipments of ore were 6,181 tons of cupreous ore, 24,271 tons of sulphur ore, and 93,582 tons of washed ore. The net profit was £34,645, which was carried forward.

Siberia. — The Ayan Corporation, Ltd., has been registered, with a capital of £300,000, to acquire alluvial gold properties on the Okotsk Sea, north of Nicolaievsk, and certain trading interests. Mr. C. W. Purington is the pioneer who has introduced this business, and he is supported by many companies identified with the Lena Gold-fields.

LAND GROWTH

By J. H. GOODCHILD

The Author outlines a method of approaching the main problems of geophysics and geochemistry.

In the April issue of the MAGAZINE a letter of mine was published, contributing to the discussion on iron ore in Cumberland. An editorial article in the same issue referred to views and arguments, leaving readers to discover that the main point of that letter was an appeal. The suggestion was made that argument should be suspended while a comparative study of iron ore regions is undertaken. The aim would not be the origin of the ore so much as a critical study of the surroundings, taking all that the iron suggests as an aid to imagination and expression. That letter and the editorial note may serve as an introduction to the following sketch. In such an irregular piece I beg that I may be excused the giving of references or making acknowledgments. It is all acknowledgment. The world is full of ideas of the kind. At the same time, for the better understanding of some allusions I must mention Professor D'Arcy Thompson's *Growth and Form*. It is no use for me to try to imitate his treatment, but it could undoubtedly be followed in the places considered. Further, those who can should refer to the following :—

(1) " A Brief Summary of the Theory of Isostasy," by Colonel Burrard. *Geographical Journal*, July, 1920, noting particularly the remarks of Mr. R. D. Oldham.

(2) " The Interior of the Earth," By Mr. R. D. Oldham. *Geological Magazine*, January, 1919.

(3) The first chapter of the second volume of *The Face of the Earth*. Ed. Suess, Oxford edition.

The exhaustive study of *The Manganese Ores of India*, by Dr. L. L. Fermor, nominally an official production of the Indian Geological Survey, and the writings of Dr. Morrow Campbell on Laterite, have been the most instructive, not to say inspiring, literature on tropical geology which has come my way.

* * * *

The elevation and depression of the land, or as Suess prefers to name the problem, the displacement of the strand line, is discussed in his second volume. The first chapter gives a history of ideas regarding it. He records that in A.D. 1320 Dante delivered a discourse " De Aqua et Terra." At the time it was generally held that there were two centres, about which the elements ranged themselves in symmetry, one for the waters of the ocean and another for the land, and these were so placed that the sea was higher. Did not the land sink below the horizon as a ship put out to sea, and was last seen by the man on the mast ? The greater height of the sea accounted for the occurrence of springs near the summits of mountains.

Dante showed that all this was untenable. Water condensed on the mountains from the atmosphere and would thus produce springs. He gave his reasons for rejecting the two centres, saying that it is evident that the land rises from the ocean owing to particular elevations of its mass, and not as a result of a general eccentricity, since in the latter case the dry land would be bounded by a circular outline, and this we know is not so. He goes on to say that the earth cannot raise itself, nor can the cause be water, air, or fire ; the elevating force must therefore be sought in the heavens.

Dante thus adopts the system which had already been expounded in greater detail by Ristoro d'Arezzo in 1282 ; according to this, not only must the irregularities of the earth's surface be ascribed to the fixed stars, but mountains and valleys present, as it were, a mirror of the various distances of these stars from the earth, in an inverted sense, like the impression of a seal in wax. In addition, Ristoro is aware of the erosive power of water, and of the existence of fossilized remains of marine animals.

Let us suppose, then, a man of that time contemplating the mountains of Italy. He sees them as particular elevations. Tradition and habit favour the view of each mountain as a separate entity with its name, but there is also probably a word like " monte " in use for high, barren land in general.

He has seen the tops of these mountains snow-capped in winter, the snow disappearing in the spring. The water sinks into the ground or runs away over the surface. In the first case, a source for springs, in the latter a force tending to develop form by cutting out ravines.

But, besides the evanescent snow, there lies on some mountains something more stable yet often curiously like patches of snow. It is, when you come near it, a whitish soft stone. It contains shells like those found in the sea. What can this mean? The sea! Wonderful thought! Could the mountain have been below the sea? Could these creatures have been buried as travellers sometimes are in a snowstorm? Could this greyish-white stone fall, settle on the mountain, harden and set like mortar? Some patches are much higher than others. And if some power did lift the mountain with this load to the upper air, how should it not bend, break, be drawn out into streaks and veins as we so often see. The outer form

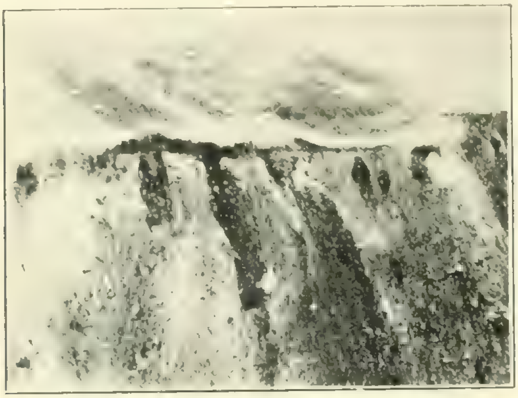

Fig. 1.—Typical Chalk Pipes.

is all jagged and scarred, and more than this, the entrails are as though one should draw out dough or clay of different colours as the potters do. And the water in the caves drops crystal! Here is no sign of water at a higher level in the sea rising through the earth. The high power we must invoke seems above. It lifts, it lifts the mountain! No, not the mountain. There is lifting, there is a drawing out, and the mountain grows to its present form as all comes up through the salt water towards the rain and cloud. Even as the snow melts, so this lime with the shells melts. Part goes through the mountains and part lies in hummocks on their sides.

*　　*　　*　　*

This was before the day of "crust," before it was easy to speak of a globe with an interior, before there had been added to all the other influences present in observation and description tending towards the choice of words like "rock" for a fraction of the crust, the additional influence of palæontology.

Our feet inform us that the ground is solid. Twenty miles of solid is solid. Then, compared with the fossil, the "rock" was a tombstone, a tablet in a record. Building-up went by rock-forming. There were *agents* which formed and destroyed. Rock by comparison was patient, not agent.

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Yet there is, of course, plenty of activity in the hills. Consider the elementary case of a chalk-pipe, one of those iron-stained shafts or pockets which so easily catch the eye in the south-east of England, where

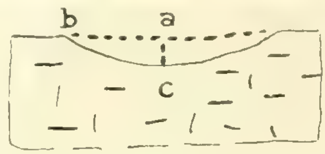


Fig. A.

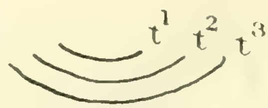


Fig. B1.

Fig. B2.

gravel and sand lie on the Chalk (Fig. 1). These pipes were considered formerly to be perhaps filled pot-holes. The flints and sand are in a "hole" in the chalk. How did they get into it? By being swirled in with water. The pipes, however, are often highly symmetrical, and Prestwich, in 1855, discussed at once their symmetry and chemical origin. He said that probably solution of the chalk took place at favourable spots, sand and flints flowed downwards, a cylindrical

shaft being formed and filled continuously. As regards the form, he thought that a pipe begins as a basin-shaped depression with depth *ac* less than radius *ab* (Fig. A). As the growth proceeds these proportions are not maintained, solution being more rapid at the bottom than at the sides, that is *ac* becomes greater than *ab*.

The pipe, therefore, does not enlarge with time, as in Fig. B1, but as in Fig. B2. It is probable that the internal processes of this cell-like growth are complicated. Very likely the iron counts for something more

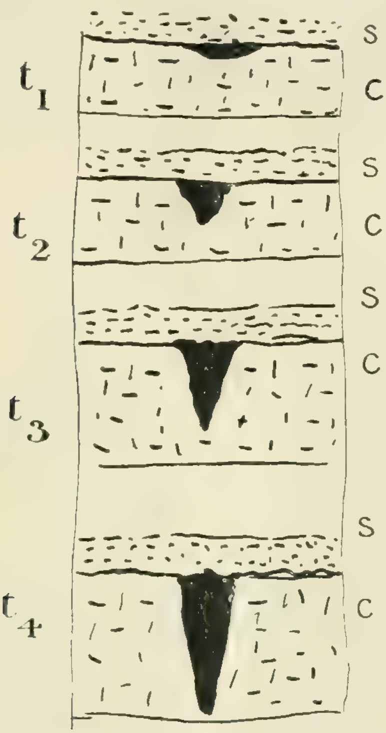


Fig. C

S = Sand C = Chalk

than an adventitious stain. Simplifying the processes, we may suppose that iron and organic matter come from the overlying sand, and so

Organic matter + iron as catalyst + oxygen + water give CO_2 + water + ferric compounds.

Ferric compounds have an affinity for silica, and tend to be retained by it as well as by the alkaline reaction of the chalk. The rhythm of the seasons may enter into the processes, leaching and diffusion being more rapid in wet weather, dry weather favouring some other necessary phase.

In any case, you have a symmetrical external form growing by balanced complicated processes within. A new thing has been born, which has a behaviour as an individual, calling for a *name* by reason of its symmetry and definite character. Many are shapeless, however, and of all degrees of definiteness, due, no doubt, to lack of just the right balance in the factors. The shapeless ones are but as part of the overlying sand, and have no name.

Taking a symmetrical case, we can think of a " growing " or " dynamic " pipe, and represent momentary states as in the diagram (Fig. C). To these alone does the notion of " rock " or " deposit " seem to apply.

The reality over the interval t_1 to t_4 is a changing thing, or, at any rate, when we say that " it grows," we are using an ordinary and well understood notion.

If enough iron, organic matter, sand, etc., enter the growing cavity, action on the chalk and growth of some kind might be continued even if communication with the surface were cut off by the closing of the orifice from any collapse or thrusting movement. If water continued to penetrate, the enclosed materials would be as so much food to be digested, and the resulting equilibrium form at the moment t_n would depend on the rates of the various happenings internal and external during the interval. The growing pipe is a kind of cell.

The following points are briefly noted :—

(1) The *colour* of the iron first attracts our attention, then helps us to visualize possible changes, and on the large or small scale would assist in following them by *comparison* of different cases.

(2) Catalytic action of the iron probable and therefore a highly suggestive example lies before us under comparatively easy conditions.

(3) These pipes occur below such a formation as, say, the Thanet Sand. They are examples of internal change or interaction between two so-called rocks, which in stratigraphy are said to be of different " age." The *law of superposition* is thus called in question.

(4) When equilibrium is reached the cell appears as a low order of *concretion*, but during growth it might be said to function as a low order of *agent*.

* * * *

Having visualized the pipe, or cell containing sand and iron, growing into the

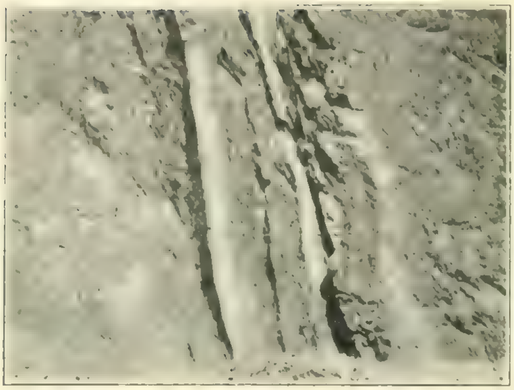


Fig. 2.—"Gashes" and "Faults" in a Calcareous Shale.

Chalk, we remember that the water and products of reaction pass away into the latter. The Chalk also with its innumerable surfaces of interaction is a scene of internal change. That impurities should be able to segregate or come to equilibrium in this region of action and freedom is not more surprising than that water should collect in streams on the free surface of the hills.

The Chalk formation which covers so large an area of Western Europe is still a kind of sea, where freedom for growth and segregation obtains, although we walk on it as solid land and are therefore liable to forget or ignore these internal potentialities when larger questions are to be considered.

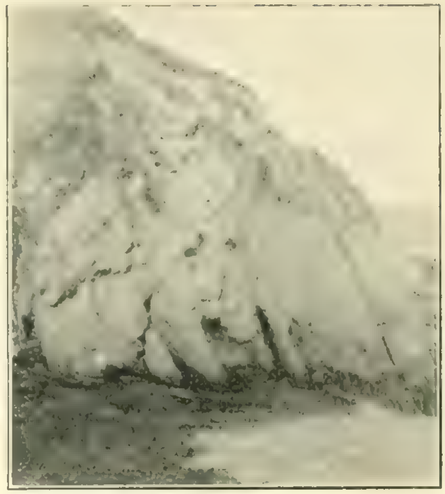


Fig. 3.—Thin-bedded Calcareous Shale near the Hill shown on the right in Fig. 5.

As the flints and sand adjusted themselves by falling to form a symmetrical cell, so the Chalk will adjust itself in "jointing" and "bedding," while solution and precipitation and other processes are taking place internally. Turning our thoughts back to the vastly greater accumulation which slowly covered the floor of the Cretaceous sea, we easily recognize that all subsequent happenings are to be related to a "dynamic chalk," something changing internally at

Fig. 4.—Massive Limestone among Calcareous Shales, Basque Country.

FIG. 5. MINING DISTRICT OF BILBAO.
Large masses of iron ore are quarried on the hilltop to the left where the limestone visible in the centre is faulted down. To the right, the valley is in less resistant shale. The conical hill has a backbone of limestone. Dykes and indefinite masses of greenstone are found in all directions but are of small dimensions.

appreciable rates. The flint veins or marcasite nodules could grow in such a medium as freely as on the open floor of the sea. No open fissure is needed for the flint vein, but at the same time " replacement " may be an expression liable to mislead. It is a reversion to the idea of a fixed place or thing to be replaced.

If so large a quantity of matter pass from solution to the solid state, from sea-water through the organisms to the great " beds " on the floor, when we recognize that these are anything but constant or enduring, are, moreover, chemically active, we are led on to grasp an idea of " growing land," something not merely piled up, consolidated, and afterwards eroded. By way of the sea, in this case, the land assimilates a vast quantity of material, which will continue to function. The land is by so much the less " dead as a stone ", the more a living body.

If Chalk lying between Greensand and Thanet Sand is a field for the growth of pipes, so the Carboniferous Limestone in Cumberland is a field for the growth of hematite. The pockets of hematite are often found below the limestone, so before forgetting the Chalk and the sand cells on its

FIG. 6. TYPICAL LIMESTONE REEF IN BASQUE COUNTRY.

upper surface, we may find similar tendencies on a lower or on any surface. [illegible] flints and sand falling down, insoluble matter or compounds being precipitated might be squeezed up or in any direction. The percolating water might take any course, but the growth of the resulting cell would not necessarily be in the same direction The squeezing of creamy clay following on solution of limestone at a contact with an aluminous rock would probably be accompanied by osmosis, diffusion, etc., and these factors would determine according to their values the precise nature of the resulting growth. Particularly a sharp separation of crystalloid from earthy substances is likely. Some of the resulting growths might be vein-like, or, in dyke form, the crystalloid compounds moving at different rates from the earthy. In other cases the segregation would be widespread and fairly uniform, partly governed by lines of bedding determined during mechanical deposition in water.

* * * *

In photo No. 2, from the neighbourhood of Bilbao, in the north of Spain, are seen "beds" of "greensand" in a calcareous shale, somewhat like our Gault, but harder, and belonging to a complex of about the same age.

Photos Nos. 3, 4, 5, and 6 give an idea of the country. As one walks these valleys one passes through the depths of an ocean bed. Since the day when the coral reefs rose and sank, were silted up and buried, a vast field for internal action has passed from saltwater conditions to freshwater conditions.

The great masses of limestone and all the disseminated carbonates in the shales and marlstones, now dissolving and creating cells or tissues for complicated changes, are representatives of potential action and instability. Such a complex could conceivably imbibe salts from sea-water and deal with them after the manner of a plant. I cannot say whether glauconite occurs, but many of the beds, such as shown in the photograph (Fig. 2), are like our greensand.

Photo No. 7 shows a dyke which is one of many related to the ophitic dolerite masses common throughout the region. Such dykes are commonly called "intrusions," yet along with these two types of greenish silicate rock, one describable as a bed, and the other suggesting the injection of molten silicate rock, there are numbers of indefinite bodies consisting sometimes entirely, sometimes only partially, of alkaline silicates. Some lie along the contact of limestone and shale, some are mixed with siliceous sinter or flint in lenses.

Taking the district by itself all the suggestions are in favour of growth within land accumulated in the Cretaceous ocean, resulting in the segregation of dolerite, trachyte, and ferrous carbonate. If some of the "greensands" are like the "greenalite" of the Lake Superior region, there seems no need to suppose volcanic exhalations accompanying sedimentation to account for their silicate composition and bedded form, as Van Hise suggests. The open space or freedom sought in such speculations is potential here through the solubility of a large part of the system.

In looking at the great masses of limestone either pure or marly, we can conceive of equal quantities slowly vanishing; the vanishing mass in its surrounding clayey envelope would be as it were a vast cell for processes of growth within. We may suppose that something of the kind is going on now in the Pacific round about coral reefs. At the same time we cannot expect that the more unstable substances would remain. Chlorides would be washed out. The evidence of the iron mines suggests that carbonaceous matter has been an important factor.

It is not surprising that in the early nineteenth century, while the notion of "rock" was strong, and there was no immediately apparent agent for the production of these internal greenstones, the volcano and the interior of the globe should be invoked.

It was a service to stratigraphy, tectonics, and palæontology to clear chemistry out of the way by a plausible theory. Externally formed beds invaded by "igneous" dykes, from inside, left the road open for rocklogic and mapping. We reap the reward of the statistics recorded in all parts of the world in a language which had two plain, easily understandable species as basis, the inside "igneous," and the externally accumulated in a free space, the "sedimentary." Intermediate varieties, difficult chemical complications had to be made to fit in or be ignored. Volcanoes could be observed, sedimentation could be observed, but chemical changes in "rock", though often suggested were too recondite, too difficult to observe for any compelling or

consistent body of evidence to be obtained concerning them. To-day so much has been done in other fields of inquiry that the attempt to treat such a region as this of Bilbao as "growing land" would not meet with so many obstacles, and it would be worth while to concentrate on this vast concretion, of which these two or three little photos give some idea. It is just the indefinite things which are so hard to record, and I have none to show.

Needless to add, French and Spanish geologists, as well as some British, have paid a great deal of attention to the "ophite," and endeavoured to shake themselves free from the incredibilities which the only available descriptive language tended to impose (Fig. 8).

Fig. 7.—[illegible]

*   *   *   *

The scale and character of possible chemical changes can be the better imagined by considering the ground opened up in mining the large iron deposits. In and about the limestone occur deposits of siderite with oxidized outcrops. Many of the quarries have removed most of the brown hematite and are down on the carbonate. Unfortunately no adequate photographs were available.

A simple theory of the origin of the ore is to suppose that at some period since the limestone masses were coral and shells poor carbonate of iron with intergrown calcite began to concentrate. There was oxidation later, giving brown, red, and purple hematite, enrichment of the carbonate below to pure siderite, which again in turn oxidized to hematite. The details, however, are complicated, and the main interest for the moment is the fact that mining reveals so much clayey decomposed ground, with evidence of slumping as in the case of the chalk pipe, that having these things to refer to in the same region as the greenstone dykes, the *general* idea of growth with unstable and chemically active limestone as a factor is well sustained. Neither the *source* of the iron nor the *source* of the alkalies in the silicates is at first of great importance until we have given full scope to this idea of *growing land*, and are ready to criticize "beds" "faults," "folds,"

Fig. 8.—[illegible] BEING PART OF THE PERIPHERY OF THE MAIN MASS OF TRACHYTE IN [illegible] MILES AWAY

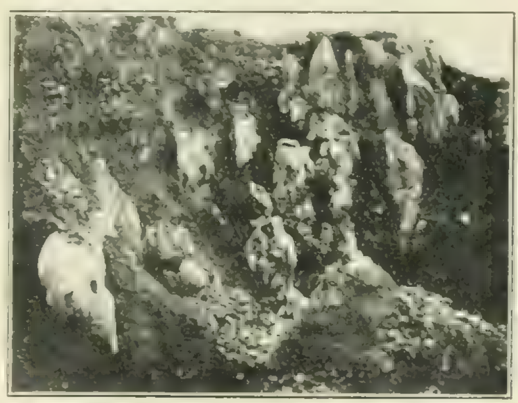


Fig. 9.—[illegible] GROW IN BETWEEN THEM

"intrusions" etc. The growth is so well illustrated by the iron deposits, and is as much to be attended to as a volcano or a river depositing sediment.

* * * *

Consider one superficial feature shown in photo No. 9. On the hard limestone lies loose earth full of brown hematite grains and nodules. The undissolved pinnacles ("dolomias") are left, showing a rhythmic advance of solution in a vertical direction. The pinnacles are often wonderfully symmetrical. In the top right-hand corner of the picture will be seen two or three of them sharply pointed, straight-sided. Far better groups exist than those here shown. The apices are conical and the sides have broad re-entrant flutes. Here there is rhythmical grouping of symmetrical cells between symmetrical pinnacles, the direction of growth in the vertical being determined by gravity. Within the loose earth the grains and nodules follow their own habits, and it is a question whether the presence of the iron has not something to do with the nicely balanced advance into the limestone, so as to produce the symmetrical pillars.

We found that a single chalk pipe, when symmetrical, called for a *name*, but I have never heard of a name for a *group* of pillars and cells, such as these. Suppose, now, instead of this coarse cellular growth in a vertical, gravitational field, some similar chemical reactions took place where everything slipped or were drawn out in long lines, the group of cells would become a tissue. Such a tissue would be fissile, cleaved, or foliated, and would call for a name such as shale, slate, or schist. These names are integrations of a property common to the whole mass; they are like summations, and somehow this summing of a series in naming works itself into our reasoning about the formation or behaviour of the tissue. That is to say, unconsciously in observation, description, or argument there is implied that the whole sum of the parts was formed by an *adding* together of the parts. These pillars grew simultaneously, and the laminæ of many shales, slates, and schists of complicated composition grew simultaneously by complicated internal processes. Of course, the textbooks warn us against confusing stratification or bedding with "cleavage", but almost on the next page the writer will probably use an argument about a "slate" which would only be valid if the cleaved layers had been added together. It is easy to imagine branching veins of quartz or pegmatite found running through a slate being formed as an excretion or as part of the growth of the tissue, so that the inference of intrusion or injection or percolation of solutions in fissures is unjustified.

Another noticeable point in connexion with these pinnacles with their pockets of earth and iron nodules is the appearance of crystallized calcite on their sides, something like wax guttering down a candle (Fig. D).

Fig D

That is to say, at some period during the growth there appears to have been a sort of reversal or halting between two alternatives on the part of the dissolving $CaCO_3$. Either solution and disappearance or recrystallization on the side of the pillar. Anyhow, it is easy to conceive of recrystallization spreading over the whole field, enclosing the nodules of iron ore, though during the process the iron might well be dehydrated and appear as brilliant flakes. The end result would be a saccharine or crystalline marble with red or black hematite streaks through it. The main point which is certain is that iron and calcium carbonate are *on the move together*.

Where large quantities of the one, the $CaCO_3$, are disappearing from the field altogether there will be forthcoming the freedom, the potential open space, for growth into permanent equilibrium forms. Such a complex might be called a "rock" or it might be called two or more rocks, depending on how the whole growth had proceeded. The symmetries developed sometimes tend to be grouped into one, so that a compound hematite-calcite rock is considered as one species. Or they might be of such a nature that the iron ore would be considered separately as a "lode" in a crystalline limestone.

The earth in the cells must not be forgotten. In the recrystallization of calcite and hematite insoluble matter would have to pack itself away between the more mobile substances.

* * * *

Intergrown red hematite and calcite showing that these two substances at least

have been on the move together is well illustrated by deposits in the province of Zaragoza, Spain. The type of ore closely resembles Cumberland hematite, and it occurs where Triassic and younger formations overlie slate or quartzite marked Silurian. At the particular spot I have in mind it seemed impossible to find any boundary between the red and green Triassic rocks and those said to be Silurian. Further, it may be remarked that in this rough and arid region, where at first the mind might be predisposed to the solid rocky view of things, the finding of soft wet hematite below ground, mine waters turbid with red oxide and depositing calcite at a great rate, is a notable contrast. When these facts have been weighed the crystalline limestones on the hillsides, with their wavy lines of hematite and curious enclosed nodules, are recognizable as probable growths within, as products of the mingling of substances from formations of different age. It is natural to ask how far such action has affected the whole region of slate and quartzite, and where chemistry is concerned what weight to give to unconformability.

Fig. 10.—Iron Quarry in Sierra Nevada.

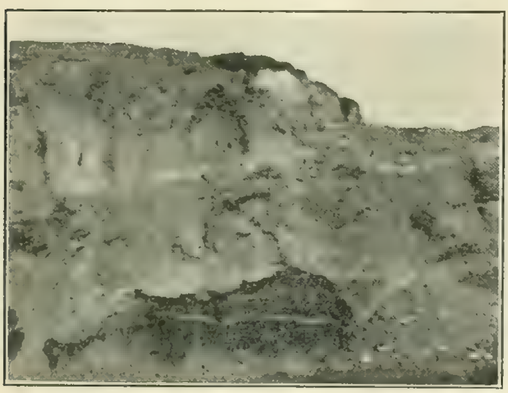


Fig. 11.—Iron Quarry in Sierra Nevada.

In the cases of the chalk pipe and the pinnacles growth occurred in a "solid" medium, or advanced through a field filled with solid. There was not the freedom of open water or of molten magma, but there was the less apparent though equally effective freedom of the unstable chalk or limestone, solid for the stratigrapher, solid for walking on, but potentially not solid when growth is being considered. So by these banded crystalline hematite-bearing limestones we are brought a further stage in grasping what changes are possible in solid-seeming, hard, dry, rocky land.

Fig. 12.—A Wady in the Sierra Alhamilla.

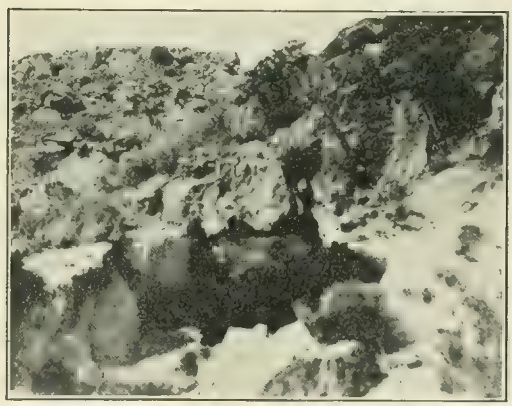


Fig. 13.—Limestone (Triassic?) lying on or in the schist shown in Fig. 12.

The action, however, has been local and incomplete. Where there has been less action the "sedimentary" strata are recognizable; but supposing it more complete and widespread, the end would have been a "metamorphic" area.

* * * *

Photos Nos. 10, 11, are from the Sierra

Nevada [illegible] near the Mediterranean coast of Almeria. The area is marked on the Spanish maps as "Estrato Cristalino," indicating a careful and philosophic reluctance to use the word "metamorphic." There are remnants of Tertiary and Triassic strata scattered over or enclosed in schists, slates, and crystalline limestones.

In the quarries shown the main mass of rock is a soft, unctuous schist, more or less "decomposed", accompanied by limestone or dolomite varying greatly in colour and texture, with splashes of hematite even more varied. The hypothesis or expression "replacement of the limestone," which serves well in Cumberland, has its weakness revealed here. It is so obvious that there is nothing fixed to be replaced. Everything is on the move, and photo No. 10 is eloquent to this effect. Notice the corner on the left, where the men and trucks are standing. From here upwards, towards the right, the dark streaks of ore are like clouds floating away across the face of the quarry, and at this particular spot there is no limestone visible; it is practically all soft schist containing these "clouds."

In No. 11 the dark mass at the bottom is purple hematite in a bed-like form, with two partings of white clay running through it. The vertical streak of white is only mud washed down the face. Notice also the sky-line. There is just an indication of the surrounding half-desert, dry, rough, and stony. Yet, not many feet down, water is encountered, with soapy rock, ready to slip and shear the while chemical change takes place in the moving medium. The ore below is mostly friable, porous, brecciated, but on the surface, of course, harder and frequently bespangled with calcite as though a sponge of hematite had been reimpregnated with calcareous solution and dried.

Everything, ore, limestone, soapy schist, wetness below, dry exterior, betokens collapse or yielding to external stresses accompanied by internal change. Most probably vast quantities of calcium carbonate and we know not what other substances besides have been leached out. During this leaching the oxide of iron has come to its present state of equilibrium, showing by the great variety of its textures and colours how sensitive it is to varying conditions. It varies from brilliant blue-black oligist to purple, brown, or yellow, more earthy forms. Needless to say that these two little pictures would require to be supplemented by hundreds of others in order to represent fully the characteristics of this region. The oxide of iron, more a dye and less a mineral, impregnates almost anything, but again seems to leave things untouched, to withdraw itself and concentrate. Note the bleached partings of white clay in No 11. Everywhere, however, the same lesson emerges, namely, that the presence of the iron makes clearer what kind of changes we have to bear in mind in considering such a region. Not only are iron and carbonates on the move as before, but siliceous materials are involved on a very large scale. The "schist" and "slate" can be imagined to be products of similar changes in less highly coloured siliceous materials. That many of the changes in the iron ore are produced by "weathering," and some of those in the schist probably deep down, need not abash us. In either case "growth" covers complicated "change of form," accompanied by "change of substance" or "metamorphism" and "metasomatism," combined and simultaneous. We are throwing away an opportunity if we neglect to make the comparison of the observable superficial deposit with those which may perhaps have grown or retain some characteristics of growth under deep-seated conditions. One suggestion is that the removal of vast quantities of matter, the carbonates, gives the *freedom* necessary for changes which are often ascribed to high temperature.

Let us now remark that these ranges of hills in this half desert region rise several thousand feet above sea-level, that patches of Tertiary strata occur at all levels, and that where the schists are exposed the remains of the Trias in many places look as though they were partly engulfed in them, and partly as though underlying schist were a sort of vertical fibrous filter on which the undissolved matter of the Trias has been caught, the soluble salts having entered into the reactions taking place in what is now schist.

You go up a deep gorge entirely in schist. Its sides show efflorescences of salts. The scanty wells often taste bitter. As you ascend to the tops of the hills you find hummocky limestone, occasionally gypsum, lying in disordered fashion across or tangled into the lines of cleavage. Photo No. 12 shows a gorge of dull-grey schist with quartz veins every few yards. No. 13 gives a rather poor idea of the limestone "caught on the filter," on the top of the hill above the

same gorge. There are signs of mingling everywhere. They are multiplied as soon as you go underground. What has happened in the vast complex which these hills represent, of which they are but the residue, since the Trias was laid down or since the Tertiaries were laid down?

There has been movement. What moved we can hardly say. Why it moved, much less. But how it moved and reacted we can in some sort make out from the present things.

There is every suggestion that in this region there has been movement through thousands of feet, and perhaps tendencies towards far greater distances never realized of materials partly accumulated in Triassic times, partly in Tertiary times, and that below the younger there has been mixture and reaction with the older, giving a streaking out into forms showing symmetries, producing this schistose complex. That these schists are Pre-Triassic or Pre-Tertiary is a statement to which it is difficult to attach any exact meaning, and for my part those "Pre-Cambrian" or "Archæan" complexes which I happen to have seen are to be looked at in the same way. How does the law of superposition apply to them? In the absence of fossils how do they come into the time scheme at all? That the Cambrian appear to rest on them means very little. Since life came to the world and calcareous matter was precipitated in large quantities in the sea, there has been a force at work renewed periodically from *above* which tends to destroy underlying things and their marks. The calcareous matter is, of course, not the only reagent at work, but it is in the observation of limestones that we are led to gather up the possibilities of internal change when unstable matter is engulfed or assimilated in the "solid" land.

Seventy per cent of the earth's surface is covered by sea. We saw in the Bilbao region that the remains of the Cretaceous there might give us some idea of the internal changes in the vast ocean bed, especially if we compared it with the Pacific of the present day.

Here, in this dry region of the south, where the very barrenness helps one to concentrate on the chemical aspect of things, where there is no antithesis of active vegetation or running streams to predispose the mind towards the solidity of rock, we are reminded by these lime-washed strata and have this reminder blazed out in colour by the iron, of the possibilities of mingling and growth in the land during its rise into mountain ranges.

In this same neighbourhood occur lava-like masses pointing to vulcanism. In the Sierra de Almagrera hot saline waters are pumped from the mines. That growth of the kind we are considering should sometimes result in violent reactions is quite easily thinkable. Salt, sulphur, or carbonaceous matter, which in other places owing to protecting influences have managed to survive as salt-beds, gypsum, or pyrites, coal or petroleum, if involved in such growth would increase the chemical potential to such a degree that local explosions might well take place. It must always be remembered that the known deposits of these substances are not quantitative samples. They are but indications of probable far vaster potential deposits, which, of course, would be the more likely ones to react with devastating consequences and their own obliteration.

* * * *

Photograph No. 14 shows the Tertiaries at Sorbas lying level in a break between the hills. They remind me of figures I have seen of the Indian Gondwana beds and their relations to the gneiss. It is obvious that isolated patches of a widespread formation may remain slightly changed while everything around may run together and produce new forms.

* * * *

If we are prepared to make the most of the phenomena of internal change, revealed in and about the mines of the Sierra Nevada region, the "estrato cristalino" becomes a kind of large concretion involving fragments of recognizable fossiliferous strata.

Those wonderful series which are so prominent in the tropics, under such names as itacolumite, Witwatersrand, Dharwar, can be viewed in the same way. They may be more perfect examples of "estrato cristalino."

* * * *

Photo No. 17, from Minas Geraes, Brazil, shows a typical outcrop of itacolumite, the famous "flexible sandstone." It is an oblique view of three parallel ridges with slate or schist between them. Close by is the well-known iron ore mass, the Pico do Itabira do Campo.

Photo No. 16 is a view of the eastern side of the Serra do Caraca. To the right, rising to 3,000 ft. above the plain, is the main mass of itacolumite. The double pointed hill

towards the left is chiefly of itabirite or hematite quartzite (Fig. 15). The plain is covered with "canga" or "lateritic iron ore."

Everyone acquainted with these regions knows that with variations such series occur over thousands of square miles, with granite or gneiss appearing at regular intervals.

In a paper entitled "Laterization in Minas Geraes, Brazil," published some years ago (*Inst. Min. Met.*, 1913-14) I gave an account of my impressions of this region. The line taken then was the same as I have tried to develop in this article. It was forced on me by the stupendous character of the "weathering" phenomena. The iron and manganese deposits bring out in such remarkable fashion the possibilities of growth that one is irresistibly led to universalize.

* * * *

A word about Lake Superior. I have never been in North America, but taking Professor Leith's word for it that the iron deposits are closely similar to those in Minas Geraes, make the suggestion that both may be Post-Cretaceous growths. That is, if it be possible to ascribe any age at all.

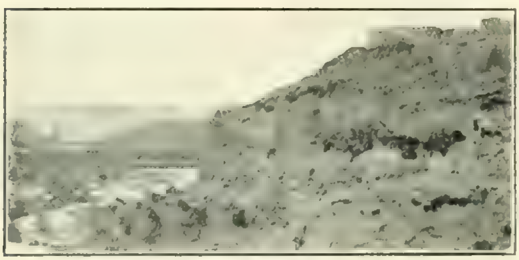


FIG. 14.—ITABIRITES AT SOBRAS LYING LEVEL IN A BREAK BETWEEN THE HILLS.

In India it has been found that underneath limestones there has been "replacement" of gneiss and other rocks. Further, there are the salt deposits of the Salt Range in Northern India, apparently Eocene, but from which it is said that the salt appears to have penetrated below the Cambrian.

My suggestion, then, with regard to Lake Superior and Minas Geraes is that since the time when these localities were in the "Pacific Phase," there has been a "drawing up of the mountain," a reaction between younger and older sediments. From this mingling and reaction is produced the "Atlantic Phase" of growth, with its crystalline rocks, its schists and banded iron ores in streaks. The deltas, lagoons, and submarine volcanoes which Van Hise professed to see in these streaks are, if I may so put it, an example of what rhythm can do in the imagination of able men, caught between a system of words and and the work of the "stars."

The freedom, the open space, required by lagoons and submarine volcanoes is potential in a system, solid for everyday thinking, but not to be thought of as solid when chemically active substances are for long

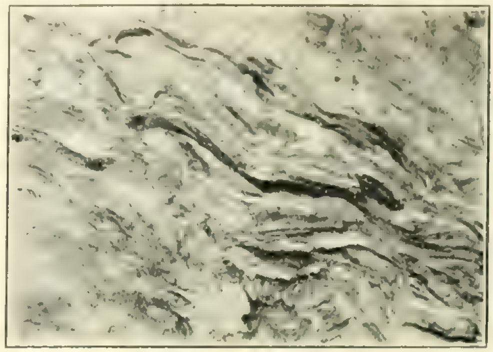


FIG. 15.—SECTION ALONG THE STRIKE OF BANDED ITABIRITE, MIGUEL BURNIER MANGANESE MINES, BRAZIL.

FIG. 16.—EASTERN SIDE OF THE SIERRA DO CARACA.

periods from t_p to t_a, in such relations as we saw obtained in the case of the sand lying on the chalk.

* * * *

We saw that the "chalk pipe" or cell helped us along with the consideration of physical and chemical changes taking place together, of falling related to solution, etc., producing definite symmetrical objects calling for a name, becoming definite members of a class or species. It led us to extend our range over great spaces to the conception of "dynamic" chalk, as a factor or agent or

organ in growing land. In a similar way, but in a way quite impossible for me to impart here, the hills of itabirite and their surroundings may brace a man up for the conception of growth on a vast scale in a system *represented* by the fossiliferous strata in places where this growth—this so-called metamorphism—has not destroyed the marks of origin. Such a "system" includes the sea-water and all other unstable elements as factors, and does not exclude, of course, influences from the interior of the globe, though since these

FIG. 17.—A TYPICAL OUTCROP OF ITACOLUMITE, BRAZIL.

are unknown they are regarded rather as factors in the "field."

*   *   *   *

Nearly all the great rivers of the world run off the Atlantic Phase to the Atlantic and Indian Oceans. Deposition of detritus predominates. To the Pacific Ocean few great rivers run down. There is a preponderance of chemical precipitation in the form of oozes and coral. When these latter are "raised" the more violent chemical or internal processes manifest themselves in vulcanism. The slower segregation of granite and the wearing down of the land until it appears as the Atlantic Phase has not proceeded to completion before the sea overtakes it, and detritus is again deposited.

*   *   *   *

Historically, at any rate, the so-called Basement Complexes of gneiss and granite are connected in thought with fusibility of alkaline silicates. It may be that we should give more attention to solubility, diffusibility, and all the suggestions which the biologist could supply as to the properties of potassium in particular. That granite and gneiss should be end products secreted downwards or tending in the main to be secreted within the land seems to accord with the known facts.

*   *   *   *

The foregoing notes and pictures are what I have to offer for consideration in connexion with a supposed organized undertaking appealed for in my letter. Readers of any experience at all will know that there is a time for logic and a time for faith, and will, I am sure, easily imagine what might be attempted on these lines by a joint effort to unify widely scattered local knowledge. My own belief is that a very wonderful and beautiful piece of work would result and that a new view of the life of land and sea is indeed opening out before us.

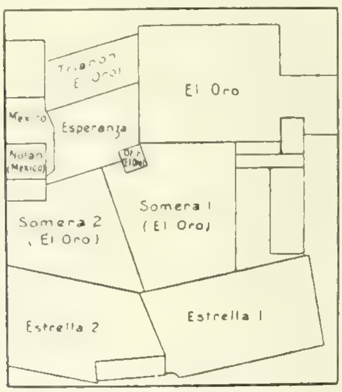
LAS DOS ESTRELLAS GOLD MINE

By T. SKEWES SAUNDERS, M.Inst.M.M.

The author describes a mine at El Oro, Mexico, of which he was manager for the last seven years. The control of this mine has been in France and Mexico, and details of the operations have not hitherto been available to English readers.

INTRODUCTION.—I have often been asked to give a description of the Dos Estrellas (Two Stars) gold mines at El Oro, Mexico, but occasion and opportunity have not been hitherto favourable. The following notes may help to complete the published information relating to an important gold-producing district of Mexico.

GEOLOGY.—Geologically the Dos Estrellas property pertains to the extensive belt of Cretaceous schists, known as the El Oro shales, that extend from the north-eastern part of the State of Michoacán to the southern part of the State of Mexico and northern part of Guerrero. These sedimentary rocks have been intruded by porphyritic rocks of Tertiary age, with the result that extensive faulting has taken place. Some of the faults follow the general strike of the veins—north-west and south-east—and are highly mineralized, thereby constituting profitable ore-bodies, as, for instance, the San Rafael vein in the El Oro camp; whereas other faults have a general easterly and westerly strike, but, although they affect the vein system in several ways, they are devoid of mineralization.



THE GOLD MINES AT EL ORO.

The Dos Estrellas Company has extensively developed a system of veins, the principal one being known as Veta Verde, which has ascending offshoots into the hanging wall, these offshoots, or branches, constituting in general payable ore. The main vein and all its branches occur exclusively in the shales and the whole shales as well as vein are covered by a cap-rock of andesitic lava, varying according to the topography of the original surface from 80 to 320 metres in thickness. Veta Verde has been proved to have a uniform width of about twelve metres to a depth of approximately 600 metres from the cap-rock. The hanging wall branch veins vary from 70 centimetres to 3 metres in width; they are approximately parallel to each other, and to Veta Verde; the westerly vein (Nueva) has a horizontal distance of about 65 metres from the main vein. In many places in the upper part of the mine the shale is mineralized to such an extent as to constitute ore, and in some instances the silver values in the shale have been higher than those in the siliceous branch veins. To the foot-wall, or east of Veta Verde are other veins, only one of which (Blanca) joins with Veta Verde in depth. The others have a width of from 0·8 to 2 metres. They are irregularly mineralized and are of little industrial importance.

The mineral filling probably resulted from the combined effect of ascending waters through previous existing fractures and by metasomatic replacement of the clastic rocks. The fractures may have been produced by shrinkage of the crustal material, aided by the effect of the intrusives.

The eruptive rocks are mainly andesitic and rhyolitic in dykes and batholiths, which, when they reached the primitive surface, spread out and covered the outcrops with the previously mentioned lava cap-rock. In the lowest working diabasic rocks have been found. The payable mineralization ceases very abruptly, and at a notably uniform level, which is slightly lower than the point where the branch veins split from the main vein, or about 500 ft. below the cap-rock.

PROPERTY OF THE COMPANY.—The company owns eight patented mining claims, having an area of 429 hectares, or practically 1,060 acres, situated on the western slope of the Somera mountain. The mine offices, mill, and cyanide plants are in the State of Michoacán, but a portion of the mining property is in the State of Mexico, and adjoins the mining claims of the El Oro Mining and Railway Co., the Esperanza Mining Co., and the Mexico Mines of El Oro.

The main vein (Veta Verde) has an average strike of N. 18 W. and a dip of about 60°

south-westerly, and has been proved for practically 3 kilometres along its strike and in places to 600 metres upon its dip. Moreover, the Dos Estrellas Company holds 60% of the stock in the old Borda Antigua property in the Tlalpujahua district (about 3 kilometres from Estrellas mill), and during the past year they acquired controlling interests in other small silver properties in the same district. As development work has proved Veta Verde to lose its mineralization in depth, the company has been actively engaged in searching for other properties, and they have options upon various properties including the Veta Grande, near the City of Zacatecas, and a copper-gold property at Las Vigas, State of Vera Cruz.

Developments.—Development has been done by six tunnels from 200 to 1,800 metres in length and by five principal shafts from 150 to 450 metres in depth. Additionally there are six interior shafts of from 150 to 300 metres in depth. There are approximately 60 kilometres of levels, of which about 38 kilometres are open at this time.

Ore Reserves.—The calculated ore reserves at December 31 of each year are shown in the following table :—

Year	*Positive* Metric Tons	*Probable* Metric Tons	Mined during year
1916	469,528	337,551	146,317
1917	213,218	84,166	277,876
1918	453,763	367,056	337,420
1919	542,920	461,292	366,440
1920	429,664	399,535	376,019

Production.—The outputs during recent years are given in the next table :—

Year	Treated Dry Metric tons	Total value of Bullion recovered Pesos	Recovered per ton Pesos	Operating costs per ton pesos
1910	425,878	11,185,443·78	26·26	9·9383
1911	479,889	11,178,096·76	23·29	9·9977
1912	507,018	11,237,311·57	22·16	9·1953
1913	521,799	10,309,630·86	19·76	9·2514
1914	141,824	2,632,526·40*	18·56	9·3550
1915	24,542	173,783·38†	7·08	
1916	164,610	2,412,288·31‡	14·65	9·2330
1917	266,658	4,917,540·62	18·44	14·4847
1918	344,859	7,719,084·06	22·38	13·4167
1919	366,820	7,615,798·05	20·76	11·5499
1920	361,878	6,415,669·98	17·73	12·1700

* Four months. † One month experimental work. ‡ Eight months.

On account of political disturbances, milling was suspended from April, 1914, until May, 1916, with the exception of one month during 1915. The total production from the mine from its inception to the end of 1920 was 4,869,878 dry metric tons.

Equipment.—Dos Estrellas has a complete electrically driven mining plant and machinery, including electric haulage, consisting of eight Baldwin Westinghouse locomotives. The milling and cyaniding plant has a daily capacity of 1,250 metric tons, and comprises two Hadfield gyratory crushers, Merrick automatic weigher, automatic sampler, 120 stamps of 1,250 lb., 108 drops per minute, 14 tube-mills 5 ft. by 24 ft., 29 r.p.m., 14 drag classifiers, 9 Dorr thickeners, Butters filters, and Merrill and Crowe vacuum precipitation plant.

The company owns its railway and rolling stock connecting its mine and mill with the El Oro camp, and also owns lumber forests in the States of Mexico and Michoacán.

History.—The Dos Estrellas property is on the western slope of the Somera mountain, whereas the famous San Rafael vein of the El Oro mining camp is on the eastern slope of that mountain, and at a horizontal distance of about 2½ kilometres from the Estrellas creek. This Somera mountain has a vertical height of about 380 metres above the western river, and on the western slope of the mountain the shale is exposed for about 125 metres above the river, the remaining 255 metres consisting of the andesitic lava cap-rock.

In the shale and at a point about 70 metres above the river, some small veins (known as "Jesus del Monte") outcrop and upon these considerable work was done in the way of test pits ; also a shaft was sunk to a depth of about 125 metres and a 220 metre tunnel was driven from the Estrellas creek for the purpose of cutting these veins in depth. This work was carried out by local Mexicans in a spasmodic manner between the years 1890 and 1897. In 1898 the attention of F. J. Fournier (a Frenchman who was at that time working in a small mining camp about 10 miles north-west of El Oro) was called to the abundance of rich float along the western slope of the Somera mountain all the way from the river to the andesite cap-rock, and he reasoned logically that such did not proceed from the narrow and poor veins of "Jesus del Monte," especially as a great deal of float was found higher up the mountain side than the outcrops of these small veins ; neither did the float come from the strong San Rafael vein on the eastern slope of the Somera mountain, the apex of San Rafael vein being about 280 metres lower than the mountain top. Fournier concluded that the vein which from the float came was buried beneath the cap-rock somewhere in the heart of the mountain but on its western slope, and, acting upon this assumption he denounced the whole of the territory available between the western

ravine and the mining claims of the three principal El Oro companies. He enlisted the services of Baltasar Muñoz Lumbier, a well-known Mexican engineer, and also organized a mining company at Mexico City in accordance with the laws of the Republic of Mexico, having as co-directors some of the best known and most successful Mexicans at that time engaged in local mining enterprises. The company was organized in 3,000 shares of 100 pesos each par value, to acquire and work the mining claims held by Fournier, for which he obtained 5,000 pesos in cash and 1,000 free or fully paid shares in the company.

Muñoz Lumbier laid out the main tunnel (now known as the Estrellas tunnel) in the shale and at a point 360 metres below the summit of the Somera mountain and about 125 metres below the cap-rock, and pointed it straight for the main shaft of the Esperanza mining property, some 2,400 metres horizontally distant. This tunnel is at a point about 320 metres south of the previously mentioned 220 metre tunnel driven earlier by the Mexicans. Work was begun on the Estrellas tunnel on December 27, 1899, and at 240 metres the "Jesus del Monte" vein was cut. A limited amount of driving proved it to be of little merit. At 585 metres a vein known as El Salto was cut, but this, too, had little importance. At 660 metres the bonanza vein (Nueva) was cut. This had a width of 2 metres, and it immediately gave shipping ore of phenomenal richness, several carloads averaging 3 kilogrammes of gold and 85 kilogrammes of silver per metric ton. At the 700 metre point the famous Veta Verde was cut, with a width of 20 metres (about 65 ft.), and averaging 25 grammes of gold and 300 grammes of silver per ton. At once Fournier's fortune was made, as well as that of those who retained their shares and accompanied him in his vicissitudes and pertinacity. As the mine was opened up the reserves developed and the surface equipment and mill expanded proportionately. The price of the shares steadily increased, and a few years later, when the price of the original shares reached several thousand pesos, these were subdivided into one hundred shares each having a nominal value of one peso each. Thus, while the capitalization remained at 300,000 pesos, the number of the shares was increased from 3,000 to 300,000. These were placed upon the Paris Bourse during 1907, and rapidly rose in price until reaching the equivalent of 38,000 pesos per share of original stock. For several weeks the price remained around the equivalent of 30,000 pesos per original share. Later on, during 1913, when it was seen that the end of the phenomenal richness was in sight, and dividends fell off considerably from previous years, a change in management was made. From 1900 to 1913 the management was confined to French and Mexican engineers. Under the management from 1913 to date extensive development work in the bottom of the mine had proved the non-persistence of mineralization in depth, and no discoveries or rich ore had been made during the past few years. Nevertheless, by employing modern methods throughout the whole organization, and by re-working the upper part of the mine, very satisfactory working costs are being obtained and the property continues to be operated profitably and to maintain the leading position among the mines in the El Oro district.

Operations During 1920. — The outstanding features of the year 1920 may be summed up as follows: (*a*) the decline in the price of silver from an average of 131 cents (U.S. currency) per ounce troy in January to 64 cents in December; (*b*) the increased difficulties in the labour situation, partly as a result of political conditions during the year, and in part due to the demand for skilled workmen in the oilfields; and (*c*) the management having obtained, by means of options and contracts, various mining properties in the Tlalpujahua and other districts, thereby taking the indicated steps towards prolonging the life and increasing the activities of the company.

Though the wages of the work-people were gradually increased, during the first-half of the year, yet there was such a demand for operatives of all kinds in the oilfields that the men became insistent in their demands, and demanded conditions economically impossible, with the result that at the end of September there was a strike that caused suspension of operations in the mill during practically the whole month of October. Although the management gained its principal points, the shut-down occasioned a higher operating cost and lower tonnage treated than would have resulted otherwise.

The policy of investigating new properties was pursued most actively, and while as a result of the big fall in the price of silver such properties have lost some of their

attractiveness, those which the company is working in the Tlalpujahua district have been acquired by long-time contracts of such a nature as to offset in part the conditions of the silver market.

The operating costs were somewhat higher than during the previous year, such being due to more development work being done, to higher wages being paid to all work-people, and to the higher first cost of the principal supplies for the mine. In spite of these conditions, the operating costs were, as usual, the lowest in the district.

During the year 3,795 metres of exploration work was done upon and in connexion with the various veins, this work being carried out upon each of the main levels between the + 90 and the −140. Although such work did not add very materially to the ore-reserves, in some instances it served to place ore from the probable to the positive class, whereas in other cases such as Veta del Salto, hanging-wall stringers of Veta Verde, and the deposit against the contact, small increases in the reserves were realized.

The ore reserves compare favourably with the reserves at the end of 1919, notwithstanding the marked difference in the price of silver at the end of 1920, as compared with the previous year. The estimates at the end of 1919 were: Positive ore, 542,919 tons, averaging 5·4 grammes of gold and 141 grammes of silver per ton; probable ore, 461,292 tons, averaging 6·4 grammes of gold and 135 grammes of silver per ton; total, 1,004,211 tons, having an average content of 5·85 grammes of gold and 138·2 grammes of silver per ton.

I estimated that at the end of December, 1920, the reserves were as follows: Positive ore, 429,664 tons, averaging 8·6 grammes of gold and 151 grammes of silver per ton; probable ore, 399,535 tons, averaging 7 grammes of gold and 152 grammes of silver per ton; total 829,199 tons, having an average content of 7·83 grammes of gold and 151·4 grammes of silver per ton.

The production for the year 1920 was 361,878 tons of an average grade of 8·9 grammes of gold and 157·5 grammes of silver. By adding this amount to the reserves at the end of 1920, it will be seen that the ore reserves decreased by only 175,000 tons, showing that approximately 187,000 tons of ore was developed during the year. This increase was brought about by actively exploiting the old stopes upon Veta Verde at various places, but principally between faults from the zero level to the + 36 level, where, in addition to finding payable fills, we frequently found small pillars of high-grade ore. To a lesser extent we are developing similar conditions on the + 72 level, north of Cyamel tunnel, and on the + 90 level towards the south end of the mine. The extent of these payable fills is unknown; hence the difficulty in estimating the tonnage they will produce, but there can be no doubt as to the importance they have upon the future of the mine. I believe that the estimates herewith given are most conservative, and that as we continue exploiting the upper part of the mine we shall continue to find payable ore in places at present inaccessible.

The following table gives an estimate of the ore reserves at December 31, 1920:—

	Positive			Probable		
		Grammes per ton			Grammes per ton	
	Tonnage	Au.	Ag.	Tonnage	Au.	Ag.
Veins:						
"A"	—	—	—	—	—	-
Ampano ...	—	—	—	16,901	6·43	103·5
"B"	—	—	—	8,700	6·19	102·5
Blanca	19,377	8·44	119·1	14,249	7·93	128·6
Colorada ..	6,240	7·25	138·2	2,000	5·50	110·0
"D"	2,016	9·89	85·9	19,300	7·48	96·9
"E"	6,769	10·76	151·5	1,717	6·59	334·0
Nueva	35,156	10·76	187·5	33,818	11·08	25 2
Verde......	360,106	8·33	149·5	282,850	6·34	151·9
Hanging-wall Stringers:						
Veta Verde		—	—	13,000	7·26	109·1
Salto	—	—	—	5,000	8·80	109·0
Mineral against Contact ...	—	—	—	2,000	8·00	62·0
Totals ...	429,664	8·59	150·8	399,535	7·00	152·0

The amount of ore treated during the year was 361,877 dry metric tons, having an average content of 8·9 grammes gold and 157·5 grammes silver. The mine produced 373,293 tons, the difference between the ore produced and the ore treated being 11,415 tons, which was added to the stock-pile at El Cedro.

The amount of bullion exported manifests an extraction of 89·2% of the gold and 70·4% of the silver contents. There was produced 1,395 bars, having a calculated value at the mine of 6,415,670 pesos.

The average price obtained for our silver throughout the year was 1·006 dollars, U.S. currency, per ounce troy, compared with 1·121 dollars during the year 1919.

Reference has already been made to some of the factors that increased our operating costs, and to these must be added that of the strike during the month of October, whereby although we treated only a small amount of ore in the mill, yet we endeavoured to keep the mine and some other departments at

work, thereby increasing the general cost of operations.

The operating costs averaged 12·17 pesos per dry metric ton during 1920, compared with 11·55 pesos during 1919. The details of such costs are herewith given, also a comparison with previous years.

	1918	1919	1920
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	4·46
[illegible]	1·23	1·29	1·21
[illegible]	2·13	[illegible]	1·81
[illegible]	[illegible]	1·17	[illegible]
[illegible]	2·15	[illegible]	[illegible]
[illegible]	0·61	[illegible]	0·51
Totals	13·41	11·54	12·17

During the year we treated in the La Lucha mill approximately 29,200 dry metric tons of ore from the Borda Antigua property, having an average grade of 5·06 grammes gold and 290 grammes silver. The recovery as per bullion exported amounted to 94·5% of the gold and 88·8% of the silver values. During the first half of the year the operations resulted in a small profit being made, but as the price of silver became lower and wages higher, it became unprofitable to continue milling operations; consequently, during the early days of December we ceased all exploitation work and cancelled the agreement between the Borda Antigua and the La Lucha companies, covering the operation of the La Lucha mill. It is the intention to treat Borda Antigua ores at the El Cedro mill when the ore in the mining properties in the Tlalpujahua district is exploited.

In the Tlalpujahua district, the company has several properties under option; these comprise Concepción de Borda, Planeta, San Rafael, and Noche Buena. On the first-named property we accomplished a considerable amount of preliminary work in the way of repairing the main shaft and roadways, unwatering the mine, and installing the necessary machinery to render the mine accessible and to carry on future development work. The results of investigations in the upper or exploited part of the mine indicate the existence of practically 10,000 tons of fills and pillars, averaging about 200 grammes silver and 1·5 grammes gold, while in the lower, or that part of the mine known as the Bonanza winze, there exists as virgin vein matter probably 5,000 tons of ore of about 300 grammes silver and 2 grammes gold. The most interesting and promising point for investigation in this property is north of the big fault, where the vein is intact, and from the second level a working is being driven to intersect the vein at this point, and at the same time to explore the ground between Concepción de Borda and the Planeta properties. The latter property has an interesting record as having produced high-grade silver ore, and we have been re-timbering the shaft and placing a hoist and head-gear in position, and will soon begin the unwatering of this property. Such upper workings as we have rendered assessible show the vein to be completely worked out.

The Noche Buena property is a small one south of the Carmen de Virgenes property. The upper part of the vein has been worked out for its gold as well as silver values, and a long tunnel that was being driven to cut the vein in depth at the time of our acquiring this property did not succeed in finding the vein, owing to it being faulted; in consequence we have been cleaning out the old workings with the view of following the vein downward by means of winzes.

We cross-cutted the entire width of the San Rafael Comanja properties toward their northern extremity, but such work did not result in our finding anything of economic importance; however, the central and southern parts of these properties remain to be explored from the Concepción and Planeta properties.

The task of cleaning out the old working of the Zomelahuacan copper property, near the town of Las Vigas, State of Vera Cruz, has been practically completed, and although the information at present available is far from being complete or final, yet the results of several hundreds of samples from various workings show that the deposits in places carry sufficient copper and gold, so as to render the exploitation of such economically possible with copper at about 15 cents. On the other hand, we now know that the mineralization does not occur in the form of a fissure vein as has previously been supposed, but rather as a contact deposit, and there is little or no continuity between the various deposits exposed which hitherto has been considered as being the case instead of isolated deposits, as we have proved them to be.

A most promising prospect containing gold values examined during the year is the El Tigre in the State of Nayarit, but unfortunately, although it was decided to enter into negotiations to acquire such property under option, legal difficulties have been experienced in the matter of obtaining a clear title to the property and have prevented its acquisition.

THE REAL VALUE OF GOLD

By S. J. SPEAK, A.R.S.M., M.Inst.M.M.

Obviously where gold is the unit of currency its value in terms of money is constant, though its real value is its value in relationship to other commodities. The true value of any commodity is equal to the energy and sacrifice required to produce it, but its market value is subject to the varying effects of supply and demand. Gold differs from all other commodities except silver, in that the demand for it is almost entirely for money purposes, so that should it ever lose its place as the basis of currency the demand for it would be almost negligible, and its market value would be subject to the usual effects of supply and demand, which would result in the closing of nearly all gold mines.

Bankers are generally agreed that some basis unit for currency is essential, and that the most suitable one is gold. Its supposed suitability depends entirely on its past history, which has been that its production has not been subject to violent fluctuations. The discovery of a large and fabulously rich goldfield would destroy its value as a basis of currency.

Gold, therefore, is unlike most other commodities in that the demand for it is mainly of an artificial character. In this respect its position compares unfavourably with that, say, of diamonds, for possesion of the latter is desired for their beauty, whereas few would hold gold on that account.

Even bankers desire to hold as little gold as possible, for without power to issue notes against the gold that they may have in their vaults, they can secure no interest upon it, and gold is therefore held by them only as an emergency precaution. Their aim is to hold as little of it as possible, in accordance with their own ideas of safety.

Thus gold is in the paradoxical position that the demand for it is of an artificial character, and no one in ordinary times wishes to hold it as a commodity.

The indifference displayed by our bankers to the dwindling gold output of the Empire shows that they regard gold mainly as an international token, and overlook the fact that gold takes much labour to produce, and that such labour has not since the war been as relatively well paid as labour in other industries. Of course, there is to be remembered the fact that a year's production of gold is only a small proportion of the world's stock of gold, and bankers may properly regard a temporary deficiency of new output as of small consequence ; yet, on the other hand, currency has been considerably increased during the war, and deflation will have to be exceedingly drastic if the world's currency can ever have the same gold backing as before the war. The declared policy of our own nation, which is no doubt dictated by the bankers, is towards that end. The paper pound is, if possible, to be made equivalent to the old gold pound.

To achieve this end strong efforts are being made to reduce the price of other commodities. The attempt with coal has resulted in a strike which has cost a loss of national wealth of probably over £200,000,000. This was a real loss, which can never be regained, because it was labour being idle instead of productive. The only gain is in the direction of improving the value of our paper currency. Deflation is obviously going to be a very expensive process, and the patient may be killed by it instead of cured.

An alternative method is to recognize the existing inflation, and thereby avoid wage reductions, which we know our workmen will stupidly resist. In comparison with American currency, ours is inflated about 30%, and it is recognized that American currency is also inflated, possibly 50%. America, as a creditor nation, having secured thereby large stocks of gold, will be able to deflate and probably at a much more rapid rate than we, and it may be expected that our exchange with America will go further against us.

Under these circumstances, if our country now recognized an inflation of 50% and adopted a free gold basis on such ratio, the immediate results would be somewhat as follows :—

(1) Wages need be little disturbed for some time.

(2) The Bank of England could purchase gold for internal requirements.

(3) American exchange would fall to near 3·24.

(4) Gold producers would receive nominally more English currency for their output.

(5) Interest payments on internal national debt would be greatly relieved. This

would not be equivalent to capital confiscation if, say, all loans, debentures, etc., raised before 1915 were allowed an increase of 50%, because most of the money raised since that date was in inflated currency. Capitalists would suffer little damage, for they would benefit by the consequent reduced taxation.

(6) All present possessors of cash or bank deposits would suffer possibly to the extent of 15%, which, anyway, is more equitable than that they should benefit to the extent of about 50% at the expense of the rest of the nation, which is what the present deflation policy aims to do.

Unfortunately such a scheme would probably hit bankers more particularly than anybody else, and it is therefore to their supposed interest to avoid it. When, however, we witness the serious trade difficulties and unemployment, and compute what national loss that means, it would probably pay all capitalists in the end to take a possible loss now, a loss more apparent than real.

For the sake of brevity, no argument is offered to show the justice of a 50% premium on gold. Your readers, however, know the general conditions of mining throughout the world, and are aware how poorly the gold miners have been paid for their work as compared with the coal miners of England. Of course, this has arisen from the effects of supply and demand.

What is now suggested amounts to legalizing a 50% premium on gold with the object of avoiding the present painful and wasteful process of currency deflation. In such way we would more quickly attain a settled basis of currency, whereas the existing deflation process must take considerable time, and may never succeed, and, in the meantime, will be a constant embarrassment to trade.

The gold output of the world has fallen about 30% since the commencement of the war, and may fall further unless the principal nations return to a free gold basis at an early date. If Great Britain will require, as has been estimated, ten years to complete its present deflation policy, by that time gold will be relatively scarce, and it will be difficult to acquire sufficient gold backing for its currency. This aspect of the question appears to be overlooked by most financial experts, and the main object of this article is to draw attention to the fact that the matter of gold production has an important bearing on the currency question. The world is an expanding community, and unless gold output keeps pace, currency deflation will have to go beyond the pre-war basis. As the British Empire is now contributing about 70% of the world's output, it is of particular interest to us to support that industry. During the war its product was commandeered at pre-war prices, a treatment served out to no other industry, and since then and is now suffering from lack of normal demand. Meanwhile, America is securing a stock of gold at a price below the fair cost of its production. The danger of the present system if continued is that when we do want gold we shall be required to pay dearly for it, whereas a bold stroke as above advocated would establish a stable currency which would enable the trade and commerce of the country to revive rapidly.

BOOK REVIEWS

A Textbook of Practical Hydraulics. By Professor JAMES PARK. Second edition. Cloth, octavo, 310 pages, illustrated. Price 21s. net. London: Charles Griffin & Co., Ltd.

That a second edition of this work should have been called for within five years after the appearance of the first is ample and satisfactory evidence that it has met the requirements of those for whom it was intended, and Professor Park is to be congratulated upon having so successfully accomplished the task that he had set himself to perform. There is but little in the present edition that calls for comment, beyond the statement that many of the deficiencies that had been noted in the first edition have now been made good. The author has, quite rightly, not departed in the least from his original scheme, although he has somewhat strengthened the theoretical portions which were decidedly weak in the former edition, as was pointed out in the MAGAZINE at the time. It may fairly be hoped that in this respect the author has found the review of his first edition not unhelpful in his work of revision. For example, in the present volume Bernoulli's theorem is stated and is applied to elucidate the theory of the Venturi meter, and in the same way the diaphragm method of measuring the flow of water in a pipe has

been, at any rate, referred to. The account of the Pitot tubes in the present volume is a decided improvement upon its predecessor ; it is, however, not quite accurate to say that when the mouth of the tube points down-stream the water in the vertical limb is depressed by the same amount as that to which it is elevated when the mouth faces up-stream. The depression is, in fact, always less than the corresponding elevation. The treatment of most of the sections is, however, quite adequate and the explanations are clearly put. To an English reader, it appears strange that in a book of this class the author should find it necessary to work out so many of his examples first by arithmetical methods and then again by logarithms. There may be a good reason for this not apparent to us in this country, but here we should have expected that a student capable of reading a work on hydraulics would at least know sufficient elementary mathematics to be able to make a simple logarithmic calculation.

HENRY LOUIS.

Petrographic Methods and Calculations. By ARTHUR HOLMES, D.Sc. Cloth, octavo, 511 pages, with diagrams and illustrations. Price 31s. 6d. net. London : Thomas Murby & Co.

Many books on petrography contain little beyond the description of the megascopic and microscopic characters of the rocks and the methods employed in their determination, but Dr. Holmes has set out to produce a treatise giving a full treatment of the petrographic methods to be employed in the laboratory and at the desk. Much of the matter appears in a British textbook for the first time.

One is struck from the first with the stimulating character of the volume. No chance of indicating a new line of inquiry is missed, and the student who can work through the book without attempting to settle some petrographic problem for himself will be very lacking in imagination.

The chapter on the determination of the specific gravity of minerals and rocks is particularly complete, and includes a description of methods for the determination of the porosity of rocks and of the specific gravity of rocks and minerals at high temperatures ; molecular volumes, isomorphism, and polymorphism are also dealt with.

The separation of minerals is discussed from every point of view except that of flotation, which seems to have been neglected by most petrographers, but in the reviewer's experience forms a useful method in some cases.

The chapters on the optical examination of minerals, sediments, crushed rocks, and thin sections are excellent, and include a most useful chapter on microchemical methods. The textures of igneous and metamorphic rocks are then described in considerable detail, and the book closes with two chapters on the interpretation and graphical representation of chemical analyses of rocks. Useful tables are given in two appendices, and a third consists of a series of excellently reproduced photo-micrographs illustrating rock textures.

Numerous illustrative examples of the methods described are quoted from actual researches and the close connexion between methods of the research-worker and those suitable for use as commercial tests of material is pointed out.

References are given throughout the book to original papers on the various methods described and on researches in which they were employed; this greatly adds to the value of the book.

The book is well illustrated by a series of figures and diagrams, the latter being particularly numerous, the print is clear, and the matter well set out.

Dr. Holmes is to be congratulated on having produced a book which should materially advance the study and practice of petrology.

E. H. DAVISON.

Chromium Ore. By W. G. RUMBOLD. Paper covers, octavo, 60 pages. Price 3s. 6d. net. London : John Murray and the Imperial Institute.

This monograph is one of a series published by the Imperial Institute describing mineral resources, with special reference to the British Empire, and it deals with the same matter as a brochure, one of a similar range, issued last year by the Imperial Mineral Resources Bureau. It is unfortunate that these two Government Departments should publish monographs dealing with like subjects, and some working arrangement between the Institute and the Bureau, to eliminate this overlapping, is desirable.

In Chapter I of the monograph, the occurrences, character, and uses of chromium ore are discussed, and attention is called to

the great increase in production during the war. For some years previous to 1914 the price of the mineral was low, and the principal producers were New Caledonia and Rhodesia, the output being controlled by a joint selling agency. With the greater demand for munitions of war, the deposits of the United States and Canada were intensively developed, and the output from the Indian deposits was also largely increased. Following the cessation of hostilities, prices fell heavily, and pre-war values are now being approached, as well as the standard of quality raised.

Chromium ores are considered to be derived from primary segregations of a peridotite magma, and are generally associated with serpentine rocks, in which they occur as irregular shaped bodies or disseminated grains. By reason of the wide distribution of serpentine, an ample supply of the ores is assured, which will meet the increased demand when conditions are more normal, for the importance of chromium has been greatly enhanced as a result of the war.

Statistics of the output of chromite for the years 1912–19 are given, but would have been improved if they had been accompanied by the value per ton of the mineral c.i.f. British ports over the same period.

The mining and concentration of chromite are briefly described, and it is pointed out that a more general adoption of modern methods would enable producers to reduce their operating costs to meet present-day conditions, as, without doubt, where mechanical concentration is not in operation, a large proportion of the mineral is rejected as waste.

The information given regarding the utilization of chromium is useful. In the production of ferro-chrome alloys in the electric furnace, the carbon contents are high, which is prejudicial when used with low-carbon steels. Subsequent refining will reduce the carbon, but a carbon-free alloy can be made by the "thermit" process of reduction by aluminium.

The virtues of the so-called "rustless steel" have been overstated, as Sir Robert Hadfield pointed out some years ago, but there is a widening field of usefulness for the alloy. As a result of improved heat treatment and variation in composition of the alloy, it is now possible to manufacture cutlery from it with an edge equal to the best high-carbon steel.

Reference is made to the use of chrome ore as a refractory material, for it constitutes an almost ideal lining for furnaces, as, although somewhat difficult to sinter, it has a very high fusing point and is equally suitable for basic or acid working. The use of chromium salts in the dyeing industry is mentioned, but it is probable the largest consumption of chromates in the future will be as a primary coating for iron and steel, which, when covered with a wet-resisting finishing paint formed of oxide of iron and linseed oil is found to be most effective in the prevention of corrosion.

Useful information is given in Chapter II, which describes the principal deposits of chromium ore of the British Empire, and in Chapter III, which deals with foreign sources of supply.

It is pointed out that some of the largest and richest deposits are within the Empire, in Rhodesia, South Africa, India, Canada, and Australasia. Of the foreign deposits, those of New Caledonia, Asia Minor, and Greece are the most important. The production of chromite in the United States reached large figures during the war, but the high cost of concentration will prevent development of the ores in normal times, as obtains with their manganese deposits.

The chromiferous iron ores of Greece and Cuba, which contain 2 to 3% of chromium and 0·5 to 1% of nickel, and which are widely distributed elsewhere, cannot be used successfully for the production of ordinary steel, owing to the extra cost of manufacture due to their refractory character, and the necessity of eliminating the greater part of the chromium in a slag, which is very viscous. A large expenditure has been incurred in developing the Cuban deposits, where the mineral occurs as a mantle, and is excavated by mechanical plant and sintered before shipment. The pig iron produced from this mineral possesses special qualities, by reason of its chromium and nickel contents, and is used as a foundry mixture to increase strength and ductility. In manufacturing steel from it by the "Duplex" process, the greater part of the chromium is oxidized, while most of the nickel is retained, with the result that the finished product contains 1 to 1·5% nickel and 0·25 to 0·75% chromium. This constitutes a nickel-chromium steel, and although of low grade, is, with suitable heat treatment, of greater value than ordinary steel for many purposes.

The bibliography at the conclusion of the monograph should enable anyone interested to obtain more detailed information than is possible to provide in the text.

H. K. SCOTT.

Geology of Mesopotamia and its Borderlands. Compiled by the Geographical Section of the Naval Intelligence Division. Cloth, octavo, 120 pages, with folding maps. Price 5s. net. London: His Majesty's Stationery Office.

Although but recently issued to the public this useful little volume betrays signs of having been written some time previously, for neither in the text nor in the excellent bibliography is there any mention made of the more recent work done in connexion with the geology of these parts, notably of the paper by Busk and Mayo read before the Institution of Petroleum Technologists. One rather obvious defect arising from its anonymous authorship is the difficulty of separating the opinions of the writers and those of their authorities.

In the note which precedes the text we find that "the problems of the economic geology of greatest present interest are those connected with the distribution and correlation of the oil-bearing beds . . ." Some space is devoted to other minerals, but the above forms the keynote of the work, with which all will agree; yet, regarded as a contribution to our knowledge of the oil of these regions, it must be confessed the book has little practical value. Thus, the evident importance attached to the fact that oil seepages have been known historically for 2,400 years (pp. 72 and 84) strikes an oil-man as scarcely justifiable, for the actual period presumably has been far greater, and in any case such considerations are little evidence of commercial supplies being retained. The fact of the development of the Maidān-i-Naftūn pool in Persia is, of course, rather a testimony to the drill than added geological evidence, and its exact significance as regards the field as a whole can be judged only from the detailed geology, which is not touched upon. Again, the evident desire for a "definite estimate of the quantity of oil" before pronouncement as to the prospects of a field shows undue caution and the practical oil-man does not concern himself mainly with the "correlation and number of the promising oil-beds" nor with the expression of opinion of writers personally unacquainted with the area.

Sound judgment formed in the field after detailed plane-table mapping by experienced oil-geologists is the kind of basis required in appraising the potential value of a prospect, and this has to be followed by systematic test drilling co-ordinated with the geological work. The favourable consensus of opinion of oil-men conversant with these regions, which tends to regard them as the principal undeveloped field in the Old World, deserves more weight than is given to it by the authors.

With the above reservations the book may be recommended to all desiring a handy compendium of the general geology of the Persian Gulf and Mesopotamian regions, based mainly upon the works of Loftus, de Morgan, and Pilgrim, with brief reference in Chapter V to Oswald's work in Armenia.

The summary of the geological history in Chapter VII is the most interesting part of the book, both as regards what is already known as well as indicating the important problems yet to be tackled, as, for instance, the southern margin of the Sunkland. The maps and diagrams are carefully made, and the former are not the least useful part of the work.

T. G. MADGWICK.

Handbook of Metllaurgy. Vol. I. By CARL SCHNABEL, translated and revised by HENRY LOUIS. Cloth, octavo, 1,171 pages, with numerous diagrams and illustrations. Third edition. Price 40s. net. London: Macmillan & Co., Ltd.

The first edition of this book was published in 1898, and the second in 1905, and both editions were translations of Schnabel's German editions with brief notices of improvements and new processes made known after the issue of the original work. In the present edition Professor Louis has taken a more original line, for he has adopted the plan of an independent revision, mainly, as he states, on account of the death of Schnabel, and because all the important modern improvements in general metallurgical practice were to be found in English-speaking countries. The war, however, delayed publication of this third edition, much of which had been completed and the type set up by 1914; "therefore," states Professor Louis in the preface, "there are no references to any of the most recent developments in certain departments . . . nor to any of the literature of the last few years." This is almost bound to impair the

usefulness of the book, at least, as far as those are concerned who already possess the earlier edition. The difficulty does not appear to the reviewer as insurmountable, for it might have been overcome by an appendix in which these matters could have been dealt with, and then incorporated in the text of the next edition.

The form of previous editions having been maintained, it will be hardly necessary to say that the present volume deals with the metallurgy of copper, lead, silver, and gold, and that in each case the physical and chemical properties and the reactions of the metal compounds that are of importance in extraction are set forth before the methods of extraction are explained in detail and illustrated by works practice.

The book deals essentially with general metallurgy, that is, with the extraction of the metal from its ores, and the necessary refining operations. Many people, including the reviewer, would have liked to see more reference to the micro-examination of metals in those sections relating to the effects of impurities. For instance, in the case of copper, photo-micrographs of this metal containing cuprous oxide could have been inserted with advantage on p. 3 where reference is made to the eutectic (a metallography term), and, further, the injurious effect of bismuth could have been explained by an illustration of this constituent separating out and forming thin brittle walls between the copper crystals.

Turning now to the methods of extraction and refining, it seems a pity, in view of the fact that an independent revision has been made, that the reviser has not been more drastic in his treatment of processes that are almost obsolete, thereby gaining space for fuller descriptions of the more modern methods and plant. A comparison of the present edition with that published in 1905 shows that the revision has not been as drastic as some would desire. The details of heap-roasting may be important, but surely not of such importance as to require ten pages to be devoted to it, when the description of the Edwards and Merton roasting furnaces is confined to a space of a dozen lines. Another example that might be quoted occurs in the section dealing with the metallurgy of lead. It is stated on p. 565 that "the collection of flue dust is an important element in all lead smelting," and with this statement all lead smelters and refiners will agree. The subject, however, is dismissed in two pages, without even a description of a bag house, the reader being referred for this to the *Transactions* of the American Institute of Mining Engineers, whereas the illustration of the heap-roasting of copper ores is reproduced under lead, a distinct waste of half a page.

It is gratifying to find that the revision of that part of the book dealing with the cyanidation of gold ores is as thorough as could be expected in a volume of this size. Had the other metals been dealt with in a similar manner the book would have been well-nigh perfect.

In conclusion it should be stated that the blame for parts of the new edition being less up-to-date than others must not be placed on Professor Louis, for it is well-known that a reviser of a technical book seldom has the last say, the control of the policy of new editions resting solely with the publishers.

GEORGE PATCHIN.

NEWS LETTERS

PERTH, W.A.

May 22.

TAXATION OF MINES.—During the past three weeks the Royal Commission on Taxation appointed by the Federal Government has been taking evidence in West Australia. The subjects of inquiry covered the equitable distribution of the burdens of taxation, and the giving to primary producers a special consideration as regards the assessment of income tax. A great mass of valuable evidence was collected and proffered on behalf of the Chamber of Mines and the Mining Association, which was most ably placed before the Commission by Mr. J. V. Jukes and Mr. Will Davies, the accountants representing the institutions. Mr. Herbert J. Daly, Mr. H. R. Sleeman, Mr. J. Thompson, M.L.A., and Mr. C. M. Harris gave evidence supplementing the above on behalf of those who are directly interested in finding the capital either in cash or labour to search for and extract gold and the base metal ores. A review of the salient points may be of interest to show to the British investor that some amelioration of the present anomalies in taxation as interpreted may be expected, provided the Federal Government is sincere, and will accept the recommendations of the Royal Commission.

The evidence as it affects the mining industry may be divided into five headings: (*a*) Decrease in the output of gold in Western Australia; (*b*) taxation of sale consideration of mining leases; (*c*) Federal land tax on the unimproved value of a mine; (*d*) the taxing of mines in their early stages; (*e*) the taxation of prospectors.

Dealing with the tax on mining leases, it was pointed out by Mr. Davies that the action of the taxation department in assessing for income tax the sale price of a mine under the guise of such being *payments received by a lessee upon the transfer of a lease to another person* is most unjust. The department admits that the proceeds of the sale of a mine are not taxable as income; nevertheless, it arrives at that very unjust result by taxing the sum received (subject to allowance for capital expenditure on equipment and development, if any) by designating it consideration given on the transfer of a lease. As the Act stands and is administered at present, the prospector who discovers a potential mine, but, being unable to develop it himself, sells it to a company for partly cash and partly shares, or for all shares, may be called upon to pay in taxes on nominal income a greater amount than will be actually realized, this state of affairs being brought about by the taxation of shares at their face value, irrespective of their actual market value, either at the date of the sale of the mine or at the date the return is made by the taxpayer.

In his evidence, Mr. Jukes says on this question that although originally intended to apply to leases of business premises, it is being interpreted in its present form as applying to mining leases, and operates with great harshness. A prospector taking up public land under mining lease may be able to dispose of his interest to good advantage through the discovery of promising deposits on it. Assume he is able to sell for £10,000, he would become liable for £3,421 Federal taxation and the State Act purports to impose £2,300, whereas, if he had won the same amount in a lottery his Federal tax would be £1,400. Of course, if instead of taking a mining lease of land he bought freehold, and then owing to some fortunate circumstance he sold at a profit of £11,000, he would not be liable to taxation on the accretion. From various legal authorities on judgments quoted, it seems impossible to regard a mineral deposit, even though contained in a mining lease, as anything but a fixed capital asset. And even if in the hands of the original discoverer who has paid no fixed sum for the asset, the facts are not affected. He has given time, money, skill, and often suffered great hardships in the search, and the State secures the mineral contents of a certain area of land to him to work, remove, and sell for his own benefit. It is what he retained in the shape of assets upon which he has expended his capital subscribed in the form of his savings, work, and skill.

In the "Kalgoorlie Miner" on October 25, 1919, the Deputy Commissioner of Taxation in dealing with what is the essential value of a lease, thereby meaning buildings, pastoral timber, or gold mining leases states: "My staff valuer would address himself to the gold as a wealth-making factor," and he goes on to say "that is the value of the virgin gold in situ." As Mr. Daly pertinently remarked, the Deputy Commissioner will have to find a superman as a staff valuer, if he is going to appraise the value of gold in situ in a newly discovered mine.

A mining lease differs from all other leases; it is, in fact, a direct licence to deplete a certain area of ground and take from it all its potential and discoverable wealth. The end of a successful mining venture means that numerous deep holes have been made into the earth's crust, and no payable ore is left in the lease. The plant and machinery is usually scrapped or sold for one-tenth part of its original cost. On this point, Mr. Sleeman says: "Sales of mining leases should not be taxed as income, whether sold by individuals or by syndicates or by companies, whether the finders or the promoters. It should be treated as other forms of property in this regard. If this be refused, then as the next best the whole history of the lease should be reviewed. Its purchase price (if any), the money and work spent upon it, the number of years represented by these, and so on. It should, however, be levied only on money when actually received and on actual saleable value of any shares received on payment. Then one could sell some shares to pay the tax on the shares. At present the tax often demands money that a man has not got, and cannot get, or he might be allowed to pay the portion of this tax in shares."

Mr. Thompson cited his own case in which he had sold a mineral lease at Yampi Sound in North-West Australia to the Queensland

Government for £30,000 worth of debentures, and, according to the Federal and State laws, he was liable for £19,000 in taxation. Not only that, but the Federal Taxation Commissioner ruled that the tax must be paid on the face value of the debentures, although he had offered to sell £100 debentures for £85. He was of opinion that as several loans had been floated locally by the Federal Government, and the debenture issues were free from taxation, why not apply the same thing to investors, who put their money into debentures or in developing the country.

Dealing with the question of taxation of unimproved land values in relation to mines, Mr. Davies was in a position to give some very telling evidence in the case of the Whim Well Copper Company. The mine of this company is held partly as freehold and partly leasehold. In the absence of a valuation for the unimproved land tax, which the company, under legal advice, refused to put in, the amount of the tax assessed in default was £4,000, despite the fact that the company had spent over £100,000 more money in developing the mine than they had taken out, and that at the time were not receiving any revenue, as owing to the war they were not able to ship any ore. Considerable argument as to whether the mine came under this Act went on between Mr. Davies for the company and the Taxation Department. Meanwhile, there was a somewhat similar case proceeding in the High Court, based on the value of artesian water below the surface, and eventually the judgment on the case was in favour of the Department. The Whim Well company had to accept this decision, as they were not in a position to fight an expensive case in the High Court. By this time the company had become bankrupt. A few London enthusiasts agreed to find some more money for the mine, but would not do so while what they considered an unjust taxation debt was hanging over the property. Mr. Sleeman, representing the shareholders who were finding this new capital, decided to go to Melbourne and fight the matter out with the Commissioner. He asked whether it was the policy of Australia to encourage mining or to kill it, and whether it was better for the Commonwealth to get £1,988 by way of taxation, or that a big mine should be producing possibly a quarter of a million pounds worth of ore in two or three years, and pay a very large portion of it out in wages? The Chief Commissioner dealt with the matter, and he annulled the whole of the assessment.

The conclusion is that, while as a matter of policy Federal land tax may be of advantage to the community by deterring the locking up of land in large estates, there is neither necessity nor reason for applying such principles to the small areas contained in metalliferous mines, no matter how rich (in isolated cases) those areas may be.

The effect of taxation on new mines was dealt with by Mr. Daly, who contends that income tax was designed as a tax on yearly earnings, on the profits of a company or individual. It certainly was never meant to be a tax on new wealth, the discovery by a prospector or by an exploration company, nor was it intended that the working capital provided to open up new mines should be subject to income tax before any profit had been earned from the gold won from the mine. This statement is given in general terms, and aims at illustrating how the mining industry has suffered a severe setback since legislation provided for tax on transfer of leases and income tax on prospectors consideration. The effects of recent Australian mining legislation have practically blocked the road to raising any new capital in London. The taxation on prospecting operations is one of the chief hindrances to new mining ventures in Australia. A few days ago Mr. Daly received the following instructions from an important London company: "We have, after careful consideration, reluctantly decided not to embark on any gold mining business in West Australia at the present time." Both the State and Federal Acts deal as harshly with mining companies as with the individual prospector.

The case of Charles Bartlow was cited by Mr. Davies. He had been prospecting for over twenty years, with but little success. Some years ago he found a small patch which yielded him some three or four thousand pounds. He put this money on fixed deposit and has been subsisting on the interest while he continued his calling as a prospector. In 1919 his income from prospecting was £40, for the next four years it was *nil*. In November, 1919, he found a rich patch at Lake Austin, which produced £7,754 worth of gold. Deducting the cost for mining and treatment, amounting to £411, his income from personal exertion was thus £7,343. His income from property, that is to

say, the interest he drew on his former find was set at £112, or total taxable income of £7,455. Out of the modest yield of his earlier nest-egg (£112) he is taxed £35 1s. as income tax from property. The tax on income from personal exertion amounts to £1,616 0s. 11d., or a total Federal tax of £1,651 2s. 9d. In addition, his State taxation was £1,647 17s., making his total tax for this year £3,298 19s. Thus he has to pay nearly half of his income. If he had realized the harshness of such an unjust tax, he would not have crushed all the ore in May and June but would have waited to June and July to bring the operations into two different taxation years. Thus he would have saved £2,000.

The Governments have realized the value of the prospector, and have spent large sums of money to foster the industry; men have been trained as metallurgists, geologists, mining engineers, etc., and their experience is an asset to Australia. But if the enterprise and grit of the man who finds the gold or base metals is strangled by unjust taxation, then the whole fabric of mining must fall.

C. M. Harris.

TORONTO

July 6.

Porcupine.—While most branches of mining industry are quiet, there is much activity in the gold camps since labour became more plentiful, and the operations of the current year will probably establish a new high record of production. Porcupine has had such an influx of labour that many have been unable to obtain house accommodation, and are living in tents. The increased efficiency of labour is indicated by the statement that the Hollinger Consolidated is now mining and milling $2\frac{1}{4}$ tons of ore daily for each man employed, whereas when efficiency was at its lowest point it was treating only $1\frac{1}{3}$ tons per day for each worker. At the annual meeting of the Dome Mines Co., on June 14, General Manager H. P. de Pencier stated that since the issue of the annual report there had been a distinct improvement in the outlook and the output had greatly exceeded their expectations. The ore recovered between the 8th and 10th levels had fully carried out the promise of the diamond-drilling, an ore-shoot 360 ft. in length having been developed on the 10th level, while diamond-drilling for 300 ft. below that level indicated even richer ore than had so far been recovered. The McIntyre closed a highly prosperous year on June 30, and a forecast of the annual report places the profits in the neighbourhood of $1,000,000, the grade of the ore reserves having been well maintained at an average of about $11 to the ton. No. 7 vein has been reached by a cross-cut at the 1,375 ft. level, where it shows a width of 20 ft. of ore, stated to carry $30 to the ton. The Allied Porcupine, capitalized at $5,000,000, has taken over fifteen mining claims, aggregating 720 acres, together with the mining plant and mill on the Three Nations property, and has begun active development with satisfactory results. New operations under way include the development of the Big Dyke and the Triplex, formerly known as the Tommy Burns.

Kirkland Lake.—This district is attracting much new capital, interest in it having been stimulated by the prospect of the construction of the proposed narrow-gauge railway. The Lake Shore during May recovered gold to the amount of $29,637 from the treatment of 1,863 tons. A rich ore-shoot is being opened up on the 600 ft. level. The proposed enlargement of the mill has been indefinitely postponed. The annual report of the Kirkland Lake for the year ending May 31 shows a profit on operations of $34,990, compared with $24,499 for the preceding year. The production was $277,007, as against $107,071. A new vein found by diamond-drilling from the 900 ft. level, has been tapped by cross-cutting, and shows gold content of $21 to the ton over a width of 7 ft. At the Bidgood a drift at the 300 ft. level has encountered good commercial ore showing visible gold. Work is in progress at the Goodfish property, about 3 miles north of the producing area, with promising results. The Wood-Kirkland has a force of men engaged in surface exploration. A mining plant will be installed. New enterprises in this field include the Lebel Lode, Ltd., capitalized at $2,000,000, which has taken up 100 acres lying north of the Lebel Oro, and the White Kirkland with $500,000 capital and a favourably located property of 130 acres. The Kirkland Lake Proprietary, which is controlled in London, appears to be about to resume active operations. Mr. S. C. Thomson, of New York, has been visiting the properties, but his report has not yet been published here.

Cobalt.—The silver-mining industry con-

tinues much depressed owing to the low price of silver. The exchange rate between Canada and the United States enables the leading producing mines to continue operations at a low rate of profit. The Nipissing, during the five months ended May, produced silver valued at $721,431, as compared with $1,731,464 during the corresponding period of 1920. The Mining Corporation of Canada is operating at capacity and storing its silver. The alterations in the mill increasing its capacity from 160 tons per day to 300 tons, with improved methods of treatment, have reduced operating costs sufficiently to enable the company to keep working in the expectation of a profit. Recent discoveries on the Buffalo property have increased the ore reserves. At the annual meeting on June 29, President J. P. Watson stated that the most important step taken during the year was the acquisition of a majority interest in the Flin Flon copper property in Manitoba, containing 16,000,000 tons of assured ore and additional possible and probable ore of 9,000,000 tons. The annual report of the Beaver Consolidated for the year ended February 26 shows an operating loss of $3,617, as compared with an operating profit of $158,215 for the previous year. The production of silver amounted to 157,274 oz., compared with 301,781. The mine, which was closed down in December, is kept pumped out ready for the resumption of operations when conditions improve.

SUDBURY.—The British America Nickel Corporation has carried through its scheme of financial reorganization, arranging for capital as follows: $6,000,000 first income bonds; $18,500,000 second bonds; and $20,000,000 common stock. Hon. Edgar N. Rhodes, of Amherst, N.S., speaker of the Canadian House of Commons, has been elected president and managing director, and Captain D. Vogt, president of the Norwegian Nickel Works, who was in charge of the company's affairs during the re-financing period, becomes vice-president and managing director for the European office. The corporation is awaiting an improvement in market conditions before reopening its mine and plants.

GOWGANDA.—At the Castle property of the Trethewey much of the surface equipment has been destroyed by fire, and the mine has been closed down. Re-financing is in contemplation before resuming operations, which will not be a matter of difficulty, as the company has 400,000 shares in the treasury.

VANCOUVER, B.C.

July 7.

MACKENZIE RIVER OIL.—The Imperial Oil Company's monoplane has made its first trip to Fort Norman oilfield. The machine started from Edmonton at the beginning of June, and made the trip in slightly over 12 hours flying time. Stops were made at Smith, Hay River, and Simpson, the water route being followed. Mr. Fullerton, the pilot of the machine, returned to Peace River by power-boat, the return trip occupying 25 days, and the round trip, including the stop at Fort Norman, less than a month. Pontoons have been added to the company's monoplanes, so that they may alight on water. This has diminished their carrying power considerably. Four new oil-boring rigs have been dispatched to Norman by the water route, so this year five holes will be bored, besides the one at Great Slave Lake. It is expected that a number of other concerns will have oil rigs in the field before the summer is over, some of which probably will be in operation.

G. P. Mackenzie, Gold Commissioner for the Yukon, has been appointed a land commissioner for the North-West Territories, in order that prospectors going to and from the Fort Norman oilfield by way of the Yukon may file their claims at Dawson, instead of having to make a special trip to Edmonton, as in the past. There are many that believe that the Yukon route is the logical route to the oilfields both in winter and summer. Steamers ply between Skagway and the Pacific coast ports throughout the year, and there is a year-round train service from Skagway to Whitehorse, over the White Pass railway. There is a passable road from Whitehorse to the new silver camp, at Mayo, and Mayo is only 350 miles from Norman.

YUKON SILVER MINES.—The Yukon Gold Co. took out more than 3,000 tons of high-grade silver-lead ore from its property at Keno Hill during the winter. The laws governing mining in the Yukon and the North-West Territories demand that ore mined in these places shall be smelted in Canada. Owing to the low metal prices at present obtaining, no smelter in Canada was willing to purchase this ore, so, by an Order in Council permission has been granted to have it smelted in the United States, and the ore is being shipped to the Selby smelter, at the head of San Francisco bay.

British Columbia Output.—The annual report of the Minister of Mines for the year 1920 has just been issued. It shows the value of the mineral production for the year to have been $35,543,084. This figure is within $50,000 of the preliminary estimate, issued early in January, though the individual items that go to make up that total are vastly different from the early estimate. As I stated at the time the preliminary estimate was issued, the output of zinc then given was far too great; the revised figures now show the estimate to have been nearly 30 million pounds in excess of the actual production. The lead output given at that time, however, was some 18 million pounds, and the copper output two million pounds too low; consequently the total value of the final estimate has come out pretty close to the preliminary one. The preliminary estimate is made before all the returns have been received, and evidently this year some of the lead output was credited as zinc. As both metals come from the same mines, the error is an understandable one.

The following table gives the mineral production for 1920, those of the preceding year being given also, for comparison:—

	1919.	1920.
Gold placer oz.	14,325	11,080
,, lode ..oz.	152,426	120,048
Silver .....oz.	3,403,119	3,337,849
Copper ....lb.	42,459,339	44,887,676
Lead ......lb.	29,475,968	39,331,218
Zinc ....lb.	56,737,651	47,208,268
Coal long tons	2,267,541	2,595,125
Coke long tons	91,138	67,792

The output of gold was 32,378 oz. less than during the previous year. This was to be expected, as the price of labour and supplies remained high throughout the year, causing the Nickel Plate mine at Hedley, one of the principal producers, to close in September. For the same reason little placer mining was done in the province. The Rossland mines, too, were closed on account of labour troubles for a considerable part of the year, and had it not been for the energetic work at the Surf Inlet mine and the opening of the new Premier mine, the gold production would have been much lower than it was. With the general reduction in the wage-scale, amounting on an average to a reduction of $1·25 per man per day, there has been a revival in both placer and lode-gold mining, and at the present time everything points to a much larger production of gold this year.

But for the production from the Dolly Varden and Premier mines the output of silver would have been much less than it was, as the Slocan district, which is the principal silver-producing district of the province, was closed by strikes during the early part of the year and by the depressed condition of the lead and zinc market towards the end, the silver from this district being obtained as a by-product in the production of lead and zinc. The consequence was that the output of the Slocan was less than half of what it was in 1919.

The output of copper was maintained through the energetic operations of the Granby company throughout the year, and of the Britannia company for the first ten months of the year. Too much praise cannot be given to the Granby company, which in the early part of the year was in a really precarious condition. A change of management in June, 1920, however, has pulled the company out of the fire. A gradual decrease in the cost of the production of copper from 18·38 cents per pound in the first half of the year to 14·01 cents for the second half was effected. This has been still further reduced this year, and at the present time copper is being produced at 12·44 cents. There is still, of course, no margin for profit at the present price of copper, but it is expected that still further reductions will be made in the cost of operation, and, now that the coal strike in Britain has been settled, there is likely to be an improvement in the price of the metal.

The increase in the lead production is due almost entirely to the output from the Consolidated Mining and Smelting Co.'s Sullivan mine at Kimberley. This is turning out to be a really remarkable mine, and last year accounted for about 26 million pounds of lead and 42 million pounds of zinc, together with more than 300,000 oz. of silver. The production of the Slocan, which used to be the lead and zinc district of the province, produced only 6 million pounds of lead and less than 4 million pounds of zinc. The reason for the low production has already been given under silver.

The slight increase in the production of coal has all come from the Crow's Nest district, where the seams are large and more cheaply worked. The output per underground employee was 797 tons, and for all employees 535 tons per man. The corresponding figures at the Vancouver Island collieries were 591 and 385 tons respectively. With these outputs per man it is difficult to understand why the retail

cost of coal remains so high. In the Crow's Nest field 101,649 tons of coal was converted into coke in behive ovens, and 67,792 tons of coke was produced. At the Granby company's by-product ovens, at Anyox, 106,969 tons of Vancouver Island coal blended with 15,755 tons of Alberta coal produced 75,690 tons of coke, 884,394 gallons of tar, 296,125 cu. ft. of gas, 151,862 gallons refined motor fuel, and 2,466,355 lb. of ammonium sulphate. [This coke does not appear to be included in the returns in the table.—EDITOR.]

The only other minerals worthy of consideration were 600 tons of manganese ore, running better than 50%, which was produced from a new discovery on Cowichan Lake, Vancouver Island, and 7,500 tons of fluor-spar, valued at $175,000, which came from Rock Candy mine, in the Grand Forks division.

Considering the depressed condition of the base metal market during the latter part of the year, the report cannot be considered as other than satisfactory. It is difficult to make any predictions for the future at this time. The Granby is practically the only copper concern operating in the province at the present time, and it will not account for more than 30 to 35 million pounds during this year. The Britannia cannot possibly get its new mill finished this year, and, considering that the Canada Copper Corporation shut down with copper at 15 cents, it is hardly likely that it will restart this year. The Consolidated Mining and Smelting Co. will produce a small amount of copper as a by-product from its Rossland gold-copper ores. It is keeping up its lead and zinc output, more than 200,000 tons of ore having been delivered at the smelter during the first half of the present year, against 383,000 for the whole of last year. It has improved its electrolytic zinc process, too, considerably, and is obtaining a much better extraction. The Premier Gold Mining Co. will have its concentrating plant and new tramway finished, and should give a much larger output than ever before. An enormous ore reserve has been developed at the Premier, and the mine may be confidently trusted to give a continually increasing output of silver and gold for some time to come. The Belmont-Surf Inlet Mines, Ltd., is opening up a new mine, about three-quarters of a mile from the present one, and it, too, should give a good account of itself. The Dolly Varden mine, which provided more than a quarter of the silver production last year, has not been reopened this year. The tenor of the ore runs about 37 oz. of silver per ton, and, with the heavy cost of maintenance of the mountain railway from the mine to tide-water, this figure gives little margin for profit at the present price of silver. The president of the company paid a visit to England with a view to obtaining capital for a concentration and cyanide plant at the mine, but the time of his visit, with the coal strike on hand and consequent waning rate in money exchange between the two places, evidently was not propitious. A considerable sum of money has to be paid off to the old company before the title of the mine is clear, and this would make it difficult to raise capital. Given a concentration plant, indications point to the Dolly Varden becoming a good property. Unfortunately, however, development work has not been maintained, and this would add considerably to the difficulty in getting money.

Mining is still very quiet in the Slocan, for the double reason that the prices of silver, lead, and zinc remain low and there is no satisfactory outlet for the product, the Consolidated Mining & Smelting Co. being able to obtain all the lead and zinc ore it requires from its Sullivan mine, and the tenor of the bulk of the ore in the Slocan renders shipping to United States smelters unprofitable, on account of the high freight rates.

NEW BOOK CATALOGUE

The Technical Bookshop of THE MINING MAGAZINE has issued a new catalogue of books relating to mining, metallurgy, geology, and kindred subjects, including oil and petroleum. This catalogue will be sent post free on application.

PERSONAL

F. O'D. BOURKE has left for Nigeria.

L. MAURICE COCKERELL left on August 3 for New York and Mexico.

JOSEPH CRANKSHAW has gone to Peru to take over the management of the New Chuquitambo gold mines.

HARVEY DODD is expected from Brazil.

B. E. FRAYLING has returned from Nigeria.

O. T. GORTON is home from Portugal.

F. R. HOCKEY, superintendent of the iron mines of the Broken Hill Proprietary, has arrived in London by way of the United States, and is now visiting the Swedish iron mines.

HENRY C. JENKINS is visiting Roumania.

FRED JOHNSON has been awarded the degree of D.Sc. by the Birmingham University.

T. J. JONES has returned from the United States.

V. F. STANLEY LOW is expected home from Sweden shortly.

D. J. MACDONALD has left for West Africa.

WILLIAM MCNEILL is back from Mexico.

PERCY MARMION has been appointed general manager in Burma for the Burma Corporation.

HUMPHREY M. MORGANS has returned from the East.

ARTHUR E. PAGE has left for the mines of the Ashanti Goldfields Corporation, West Africa.

G. ROOSE PATON has left for Nigeria.

H. G. PAYNE has left for Rhodesia.

JOHN POPE has gone to South Africa.

ALBERT REIS is back from Spain.

H. F. G. ROOSE is back from Colombia.

T. SKEWES SAUNDERS has resigned as manager of Las Dos Estrellas, El Oro, and has opened an office as consulting mining engineer at 525 Edificio La Mutua, Mexico City.

F. F. SHARPLESS has been appointed secretary of the American Institute of Mining and Metallurgical Engineers. He will be remembered in this country as American representative of the Consolidated Mines Selection Company. As to his personal character it may be said that he does credit to his Quaker parentage.

R. G. STICKLAND is expected shortly from Sarawak.

S. C. THOMSON has been appointed consulting engineer to the Kirkland Lake Proprietary Company.

J. B. TYRRELL has been elected chairman of the engineering section of the American Association for the Advancement of Science, which will hold its next meeting at Toronto in December.

ARTHUR L. WALKER, professor of metallurgy in the Columbia University, is on holiday in Europe.

A. T. WATSON has gone to the Gold Coast for the Goldfields of Eastern Akkim

P. B. WAUGH is now resident in Hungary.

A. HOWELL WILLIAMS has returned from Chile.

ERNEST WILLIAMS is back from Canada.

CHARLES H. EDEN, vice-chairman and managing-director of Vivian & Sons, Ltd., Swansea, died on July 28.

WILLIAM CROSLEY died on July 31. He was for many years in the service of Edmund Davis, and was well known in West Africa as manager of the Abbontiakoon and Prestea Block A.

CORNWALLIS F. H. SMITH, for nearly 50 years on the City reporting staff of *The Times*, died last month. He was well known in many circles where his wide knowledge and accuracy of style were fully appreciated. As a reporter of company meetings he was unexcelled, Mr. Chisholm, of the *Mining World*, being his only rival.

TRADE PARAGRAPHS

The works of the METROPOLITAN-VICKERS ELECTRICAL CO., LTD., at Trafford Park, Manchester, were described and illustrated in the *Iron and Coal Trades Review* for July 15.

HYATT, LTD., of 4 Thurloe Place, South Kensington, London, S.W. 7, send us their latest sectional catalogue showing the application of their roller bearings to elevating and conveying machinery.

The WOLF SAFETY LAMP CO. (WM. MAURICE, LTD.), of the Star Works, Leeds, send us particulars of their acetylene lamps; and the FEDERATION LAMP CO. (WM. MAURICE, PROPRIETOR), send us a pamphlet relating to their new electric miners' lamp.

DANIEL ADAMSON & CO., LTD., of Dukinfield, near Manchester, send us a pamphlet giving a brief account of the expansion of their business since its foundation in 1851, and of some of their specialities: steam-engines, turbo-blowers, air-compressors, etc.

A. J. M. SHARPE, at one time with the Broken Hill Associated Smelters, and more recently managing director of H. S. Willcocks & Co., Ltd., has established the INTERNATIONAL METAL SERVICE, with offices at 13–14, Walbrook, London, E.C. 4. The object of this service is to supply commercial and technical information relating to mines, ores, metals, chemical products, etc.

THE SULLIVAN MACHINERY CO., of Chicago (London Office: Salisbury House, E.C. 2), send us Bulletin 78*a*, which describes their dry vacuum pumps of single-cylinder type. These are equipped with the Sullivan improved wafer-type plate valve for both intake and discharge openings. They are built for steam or belt driving. All the moving parts are enclosed and are fully lubricated by the splash method.

METAL MARKETS

COPPER.—The standard copper market in London at the beginning of July exhibited quite a firm tone, but later on values receded. The chief feature in the situation has undoubtedly been the appreciation of the dollar, which tended to restrict demand from Europe, and by curtailing the United States' export sales caused weakness in the New York quotation, and a sympathetic easiness here. As regards the London market, there is little doubt that the firm manner in which values held up during the coal stoppage discounted the improvement in consumption which was expected to follow the settlement, and although some slight improvement has been noticeable of late, it has not been sufficient to sustain values, which have been ruling at below the American parity. America, of course, is and must continue to be, the dominating influence, and much will depend on the attitude of producers there. The latter recently have shown rather more willingness to shade prices, and it may be that they have at last realized that the only way to restore the industry to a firm basis will be to cut down costs and reduce prices. The present United States output is, of course, drastically restricted, and only the vastness of the stocks in existence there and the paucity of world demand prevent its effect being felt at the present time. With regard to European demand, both France and Germany are taking fair quantities; and in this connexion it is rather surprising that Germany should be the chief foreign purchaser of American electrolytic at the moment, bearing in mind that she has to pay in cash owing to the fact that the credit scheme of the Copper Export Association has not been applied to her. Reports from Huelva are to the effect that the copper mining industry there is in a not too hopeful condition, but, in response to an appeal from the management the workmen have volunteered to work extra time without pay. A report from Australia states that there is no possibility of immediate resumption of smelting at the Hampden Cloncurry, unless a substantial reduction in wages, freights, and stores is effected.

Average price of cash standard copper: July,

DAILY LONDON METAL PRICES: OFFICIAL CLOSING

Copper, Lead, Zinc, and Tin per Long Ton;

COPPER

	Standard Cash	Standard (3 mos.)	Electrolytic	Wire Bars	Best Selected
July	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.
11	72 10 0 to 72 12 6	72 10 0 to 72 12 6	76 10 0 to 77 10 0	76 10 0 to 77 10 0	73 0 0 to 75 0 0
12	72 0 0 to 72 2 6	72 2 6 to 72 5 0	76 10 0 to 77 10 0	76 10 0 to 77 10 0	72 10 0 to 74 10 0
13	72 2 6 to 72 5 0	72 5 0 to 72 7 6	76 10 0 to 77 10 0	76 10 0 to 77 10 0	72 10 0 to 74 10 0
14	71 12 6 to 71 15 0	71 15 0 to 71 17 6	76 10 0 to 77 10 0	76 10 0 to 77 10 0	72 10 0 to 74 10 0
15	70 17 6 to 71 0 0	71 2 6 to 71 5 0	75 0 0 to 76 0 0	75 0 0 to 76 0 0	71 0 0 to 73 0 0
18	70 10 0 to 70 12 6	70 17 6 to 71 0 0	74 10 0 to 75 10 0	74 10 0 to 75 10 0	71 0 0 to 73 0 0
19	70 2 6 to 70 5 0	70 10 0 to 70 12 6	74 10 0 to 75 10 0	74 10 0 to 75 10 0	70 0 0 to 72 0 0
20	70 5 0 to 70 7 6	70 15 0 to 71 0 0	74 10 0 to 75 10 0	74 10 0 to 75 10 0	70 0 0 to 72 0 0
21	70 7 6 to 70 10 0	70 17 6 to 71 0 0	74 10 0 to 75 10 0	74 10 0 to 75 10 0	70 0 0 to 72 0 0
22	70 17 6 to 71 0 0	71 5 0 to 71 7 6	74 10 0 to 76 0 0	74 10 0 to 76 0 0	71 0 0 to 73 0 0
25	70 0 0 to 70 2 6	70 7 6 to 70 12 6	74 10 0 to 75 10 0	74 10 0 to 75 10 0	71 0 0 to 73 0 0
26	70 0 0 to 70 2 6	70 7 6 to 70 10 0	75 0 0 to 77 0 0	75 0 0 to 77 0 0	70 10 0 to 72 10 0
27	70 0 0 to 70 2 6	70 7 6 to 70 10 0	75 0 0 to 77 0 0	75 0 0 to 77 0 0	70 10 0 to 72 10 0
28	70 0 0 to 70 2 6	70 7 6 to 70 10 0	75 0 0 to 77 0 0	75 0 0 to 77 0 0	70 10 0 to 72 10 0
29	70 5 0 to 70 7 6	70 12 6 to 70 15 0	75 0 0 to 77 0 0	75 0 0 to 77 0 0	70 10 0 to 72 10 0
August					
2	70 5 0 to 70 7 6	70 12 6 to 70 15 0	74 10 0 to 76 10 0	74 10 0 to 76 10 0	70 5 0 to 72 5 0
3	70 2 6 to 70 5 0	70 10 0 to 70 12 6	74 10 0 to 76 10 0	74 10 0 to 76 10 0	70 5 0 to 72 5 0
4	70 2 6 to 70 5 0	70 10 0 to 70 12 6	74 10 0 to 76 10 0	74 10 0 to 76 10 0	70 5 0 to 72 5 0
5	70 5 0 to 70 7 6	70 12 6 to 70 15 0	74 0 0 to 76 0 0	74 0 0 to 76 0 0	70 5 0 to 72 5 0
8	70 0 0 to 70 2 6	70 7 6 to 70 10 0	74 0 0 to 75 10 0	74 0 0 to 75 10 0	70 5 0 to 72 5 0

1921, £71 4s. 4d.; June, 1921, £71 18s. 2d.; July, 1920, £90 5s. 6d.; June, 1920, £88.

TIN.—A drifting tendency has been noticeable in the London standard tin market during the past month, and after a slight rally at the commencement values steadily receded. Consumption during July was consistently poor, chiefly owing to the non-appearance of the expected revival in the tinplate industry. With genuine consumers practically out of the market, the standard market was inevitably dominated by the tactics of professional operators who are apparently unwilling to give the market much support. At one time a little inquiry was seen from the United States, no doubt inspired by the proposal to impose a duty of 2 cents per lb. on imported tin, but on the whole American demand has been quiet, neither the fall here nor the drop in sterling exchange succeeding in attracting any serious buying interest. The Continent, however, has been a moderate purchaser of late. As regards the East the belief that production there is somewhat in excess of current demand seems to be confirmed by the greater willingness to sell, which is now apparent in the Straits. Fair quantities, indeed, have been disposed of there at comparatively reasonable prices. The future of the market is a little obscure at the present time, as, although the quotation may not necessarily be exorbitant, the existence of large, tied-up stocks in the East and the probability of a further surplus accumulating cannot be regarded with much optimism.

Average price of cash standard tin: July, 1921, £164 13s. 1d.; June, 1921, £167 12s. 10d.; July, 1920, £262 1s. 5d.; June, 1920, £250 18s. 6d.

LEAD.—Remarkable steadiness was the feature of the lead market in London during the month of July, and values on balance were little changed. A fair amount of speculative activity of a bullish nature was evident, but this factor alone hardly accounted for the firm appearance of the market. Holders have continued their firm attitude, while consumers have also maintained their previous policy of buying mainly for immediate delivery. The net result has been that not only has the concentration of consumers' demand upon the prompt position been a sustaining factor, but that whenever delayed shipments entailed a shortage of near metal, values rose appreciably. Under these circumstances, the early position still commands a fair premium over forward. Consuming demand, on the whole, has been much better in this market than in most of the other metal markets. Indications are not lacking that possibly the near future will see larger arrivals of lead, and it is quite probable that Spain will cease to feature as the sole supplier. Indeed, during July metal arrived here both from Australia and America, and should Mexico continue to dispatch fair quantities of metal into the United States, further shipments from the latter country are to be expected. As regards Australia, it is not believed that Broken Hill consignments on any scale are possible for some time yet. In America the market has been easy on the whole, and some interests have withdrawn owing to the fact that the present prices mean a considerable loss. Quite possibly further cuts will be made in the United States output.

Average price of soft pig lead: July, 1921, £23 5s. 10d; June, 1921, £22 9s. 1d.; July, 1920, £35 9s.; June, 1920, £35 1s. 4d.

SPELTER.—The course of values in the London spelter market during July was steadily downwards, although the net loss was not considerable. This seems to have been due to the continuance of an extremely poor consuming demand and rather more willingness on the part of holders to liquidate. Probably some holders have got tired, which is not surprising in view of the present poor industrial outlook and the complexity of the spelter situation. The expected revival in the galvanizing industry has not yet materialized to any extent, and, indeed, seems impossible just at present, and therefore very little improvement can be expected in genuine consumptive demand. On the other hand, supplies have continued restricted. The Silesian question is still undecided, and what with the Reparations Act and the German-Polish dispute, fresh supplies are unlikely from that quarter for some time. Belgium and Norway have recently displayed a

PRICES ON THE LONDON METAL EXCHANGE.
Silver per Standard Ounce; Gold per Fine Ounce.

Lead: Soft Foreign	Lead: English	Zinc (Spelter)	Standard Tin: Cash	Standard Tin: 3 mos.	Silver: Cash	Silver: Forward	Gold	
£ s. d. £ s. d.	£ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	d.	d.	s. d.	July
23 2 6 to 23 0 0	24 10 0	26 17 6 to 27 7 6	166 0 0 to 166 5 0	168 10 0 to 168 15 0	36¾	36⅝	112 10	11
23 2 6 to 23 0 0	24 10 0	26 15 0 to 27 7 6	166 5 0 to 166 10 0	168 5 0 to 168 10 0	37	36½	113 4	12
23 2 6 to 23 0 0	24 10 0	26 12 6 to 27 7 6	166 15 0 to 167 0 0	169 0 0 to 169 5 0	37¾	37⅛	112 9	13
23 5 0 to 23 2 6	24 10 0	26 10 0 to 27 5 0	166 5 0 to 166 10 0	168 5 0 to 168 10 0	37¾	37⅛	113 2	14
23 7 6 to 23 5 0	24 15 0	26 5 0 to 27 0 0	165 10 0 to 165 15 0	167 15 0 to 168 0 0	37¾	37⅛	113 4	15
23 7 6 to 23 5 0	24 15 0	26 5 0 to 27 0 0	164 10 0 to 164 15 0	166 15 0 to 167 0 0	37⅝	36¾	113 9	18
23 10 0 to 23 5 0	24 15 0	26 0 0 to 26 15 0	161 10 0 to 161 15 0	164 0 0 to 164 5 0	37⅜	36¾	115 0	19
23 10 0 to 23 5 0	25 0 0	26 0 0 to 26 12 6	160 0 0 to 160 5 0	162 5 0 to 162 10 0	37	36½	114 4	20
24 2 6 to 23 12 6	25 5 0	25 10 0 to 26 5 0	161 0 0 to 161 5 0	163 0 0 to 163 5 0	38	37¼	114 11	21
24 2 6 to 23 12 6	25 5 0	26 0 0 to 26 15 0	162 15 0 to 163 0 0	164 15 0 to 165 0 0	38	37¼	114 9	22
23 17 6 to 23 10 0	25 5 0	25 15 0 to 26 10 0	160 15 0 to 161 0 0	162 15 0 to 163 0 0	38¾	38¼	114 8	25
23 10 0 to 23 2 6	24 15 0	25 12 6 to 26 7 6	158 5 0 to 158 10 0	160 5 0 to 160 10 0	38¾	38⅛	114 10	26
23 2 6 to 22 17 6	24 10 0	25 12 6 to 26 7 6	158 5 0 to 158 10 0	160 5 0 to 160 10 0	39	38¼	114 10	27
23 12 6 to 23 2 6	24 15 0	25 12 6 to 26 7 6	159 5 0 to 159 10 0	161 5 0 to 161 10 0	39½	38¼	114 10	28
23 7 6 to 23 0 0	24 15 0	25 19 0 to 26 5 0	159 15 0 to 160 0 0	161 15 0 to 162 0 0	38⅞	38	115 2	29
								Aug.
23 12 6 to 23 2 6	25 0 0	25 5 0 to 26 2 6	158 10 0 to 158 15 0	160 10 0 to 160 15 0	38⅞	38⅛	115 5	2
23 15 0 to 23 7 6	25 0 0	25 0 0 to 25 15 0	157 10 0 to 157 15 0	159 15 0 to 160 0 0	38¾	38⅛	115 5	3
23 15 0 to 23 7 6	25 0 0	25 5 0 to 26 0 0	158 0 0 to 158 5 0	160 0 0 to 160 5 0	38¾	38½	115 1	4
24 0 0 to 23 10 0	25 5 0	25 10 0 to 26 7 6	159 5 0 to 159 10 0	161 5 0 to 161 10 0	38¾	38¾	114 2	5
23 15 0 to 23 7 6	25 0 0	25 15 0 to 26 10 0	161 10 0 to 162 0 0	163 10 0 to 162 0 0	38½	37¾	113 3	8

little more desire to sell and moderate quantities have come in. The stocks in the United Kingdom are not particularly extensive, but are quite ample to meet the poor demand which at present exists. Production in Belgium is still restricted and was some 4,370 tons in June, against 4,360 tons in May. In the United States the market has been dull, and the position there does not inspire much confidence. At the moment, however, conditions are hardly favourable for shipments of surplus metal from that country to this side.

Average price of spelter: July, 1921, £26 12s.; June, 1921, £27 2s. 2d.; July, 1920, £42 13s. 3d.; June, 1920, £42 2s. 11d.

ZINC DUST.—Prices are fairly steady; high-grade Australian £55 per ton, English 92 to 94% about £52 10s., and American 92 to 94% £52 10s.

ANTIMONY.—English regulus has kept very steady; ordinary brands £37 to £40, special brands £38 5s. to £42, and 98 to 99% £29 to £32. Foreign in warehouse shows a slight advance on the month at £24 10s. to £25 per ton.

ARSENIC.—The market has continued dull, and the quotation for Cornish white is nominal at £45 per ton, delivered London or Liverpool.

BISMUTH.—No recent change has been made in the quotation, which continues at 7s. 6d. per lb.

CADMIUM.—The price continues at 6s. to 6s. 3d. per lb.

ALUMINIUM.—The quotation is about £115 to £125 per ton.

NICKEL.—Producers quote £190 for both home and export, but this price is somewhat nominal.

COBALT METAL.—The price is nominally 15s. to 16s per lb., but there are sellers at slightly less.

COBALT OXIDE.—Black oxide is still quoted at 12s., and grey is also unchanged at 13s. 6d. per lb.

PLATINUM AND PALLADIUM.—Platinum is unchanged, manufactured material being priced at £20 and raw at £17 per oz., while palladium is also steady, with manufactured metal quoted at £20 and raw at £15.

QUICKSILVER.—The market is quiet, and values are slightly lower at about £10 17s. 6d. per bottle.

SELENIUM.—Sellers quote 10s. 6d. to 13s. per lb.

TELLURIUM.—The quotation is easier at 80s. to 90s. per lb.

SULPHATE OF COPPER.—The quotation is unchanged at £30 per ton, for both home and export.

MANGANESE ORE.—The price of Indian grades is rather nominal at 1s. 2d. per unit c.i.f. U.K.

TUNGSTEN ORE.—The market is quiet and variable. The present quotation for 65% WO_3 is about 12s. 6d. to 13s. 6d. per unit.

MOLYBDENITE.—The quotation is dull and rather nominal at 42s. to 50s. per unit c.i.f.

CHROME ORES.—Indian and African grades have eased slightly to £4 10s. c i.f.

SILVER.—The London silver quotation was firmer during the month of July. The price opened at 35¼d. on the 1st, rose to 37½d. on the 9th, relapsed to 36¾d. on the 11th, advanced to 37¾d. on the 13th, and then fell to 37d. on the 20th. Subsequently the quotation was marked up to 39½d. on the 28th, followed by 38¾d. on the 29th. The price closed the month on July 30 at 39½d.

GRAPHITE.—Madagascar, 80 to 90%, has kept very steady at £20 to £25 per ton c.i.f.

IRON AND STEEL.—The resumption of operations on the part of producing plants, since the settlement of the coal dispute, has been slow. This is mainly accounted for by the price of coal, which is still too high to permit of economic working. A very few blast-furnaces have been started, and the product of most of these is for use in the same plants. Most ironmasters are reluctant to resume production till they see a chance of doing so at a profit, and a substantial reduction in coke prices will be necessary if the prices of home producers are to be on a competitive basis with Continental offers. The stocks of good grades of foundry iron in makers' hands are very low, as a result of the protracted stoppage of production In the case of manufactured material the delay in starting is no doubt partly attributable to lack of sufficient orders to permit of regular working. There is a certain amount of inquiry about, but business is slow to mature. Keen competition is still in evidence on the part of the Continent, and a fair amount of Continental material is changing hands.

STATISTICS

Production of Gold in the Transvaal.

	Rand	Elsewhere	Total	Price of
	Oz.	Oz.	Oz.	Gold per oz.
				s. d.
June, 1920	[illegible]	[illegible]	[illegible]	1[illegible]2 6
July	[illegible]	[illegible]	[illegible]	105 0
August	[illegible]	18,479	[illegible]	112 6
September	[illegible]	[illegible]	[illegible]	[illegible] 0
October	[illegible]	[illegible]	[illegible]	117 6
November	[illegible]	[illegible]	[illegible]	117 6
December	617,549	14,666	632,215	115 0
Total, 1920	7,949,038	204,587	8,153,625	—
January, 1921	637,425	14,168	651,593	105 0
February	543,767	14,370	588,137	103 9
March	656,572	14,551	671,123	103 9
April	665,309	16,073	[illegible]	103 9
May	[illegible]	[illegible]	687,776	103 9
June	[illegible]	[illegible]	[illegible]	107 6

Natives Employed in the Transvaal Mines.

	Gold mines	Coal mines	Diamond mines	Total
June 30, 1920	179,827	13,036	4,596	197,459
July 31	[illegible]	13,005	4,521	191,713
August 31	[illegible]	13,535	4,244	187,042
September 30	163,132	13,716	4,323	181,171
October 31	159,426	13,858	4,214	177,498
November 30	158,773	14,245	3,504	176,522
December 31	159,671	14,263	3,340	177,274
January 31, 1921	165,287	14,541	3,319	183,147
February 28	171,518	14,697	1,612	187,827
March 31	174,364	14,906	1,364	190,634
April 30	172,826	14,908	1,316	189,050
May 31	170,595	14,510	1,302	186,407
June 30	168,152	14,704	1,317	184,173

Cost and Profit on the Rand.

Compiled from official statistics published by the Transvaal Chamber of Mines.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
June, 1920	2,146,890	31 10	25 2	6 8	692,510
July	2,194,050	33 6	24 6	9 0	985,058
August	2,057,560	36 11	25 0	11 11	1,226,906
September	1,950,410	38 11	25 6	13 5	1,276,369
October	1,871,140	39 9	26 1	13 8	1,278,385
November	1,799,710	40 2	26 [illegible]	13 1	1,255,749
December	1,797,970	39 11	26 8	13 3	1,193,672
January, 1921	1,895,235	35 0	26 3	8 9	829,436
February	1,575,320	35 6	28 6	7 0	550,974
March	1,958,730	34 5	26 1	8 4	813,636
April	1,991,815	34 5	25 10	8 7	854,533
May	1,955,357	35 3	26 2	9 1	889,520

Production of Gold in Rhodesia.

	1919	1920	1921
	£	oz.	oz.
January	211,917	43,428	46,956
February	[illegible]	44,237	40,816
March	225,808	45,779	31,995
April	213,160	47,090	47,858
May	218,057	46,266	48,744
June	214,215	45,054	49,466
July	214,919	[illegible]	—
August	[illegible]	48,740	—
September	223,719	45,471	—
October	204,184	47,343	—
November	180,462	46,782	—
December	158,835	46,190	—
Total	2,499,498	552,498	271,825

Transvaal Gold Outputs.

	May		June	
	Treated Tons	Yield Oz.	Treated Tons	Yield Oz.
Aurora West	10,850	[illegible]†	[illegible]	£15,182*
Brakpan	54,500	22,795	53,700	20,971
City Deep	86,000	37,251	85,500	36,128
Cons. Langlaagte	39,000	[illegible]†	[illegible]	[illegible]*
Cons. Main Reef	[illegible]	[illegible]	[illegible]	[illegible]
Crown Mines	188,000	[illegible]	190,000	[illegible]
D'rb'n Roodepoort Deep	27,500	9,638	27,000	9,195
East Rand P.M.	130,000	35,858	123,500	33,034
Ferreira Deep	33,100	10,967	32,300	10,620
Geduld	46,000	15,670	44,500	14,815
Geldenhuis Deep	48,637	13,240	45,668	12,423
Glynn's Lydenburg	3,370	[illegible]§	[illegible]	[illegible]
Goch	16,300	£20,162†	17,300	£19,946*
Government G.M. Areas	134,000	£280,030†	129,000	£275,556*
Kleinfontein	47,700	[illegible]	[illegible]	[illegible]
Knight Central	27,500	7,167	28,100	68,816
Langlaagte Estate	38,500	[illegible]†	[illegible]	[illegible]*
Luipaard's Vlei	20,770	£24,112†	21,550	£26,866*
Meyer & Charlton	13,700	£42,166†	13,000	£41,056*
Modderfontein	88,000	43,689	96,000	45,103
Modderfontein B	58,000	32,938	57,500	32,556
Modderfontein Deep	41,300	23,233	42,600	23,884
Modderfontein East	24,000	10,353	24,100	9,753
New Unified	11,060	£13,202†	11,200	£13,571*
Nourse	42,200	13,999	42,000	13,561
Primrose	20,900	£23,307†	21,600	£23,814*
Randfontein Central	121,000	£183,779†	123,500	£201,427*
Robinson	38,500	8,035	42,000	7,905
Robinson Deep	59,000	18,147	56,300	17,404
Roodepoort United	22,400	£23,000†	22,200	£24,434*
Rose Deep	52,000	13,705	53,500	13,876
Simmer & Jack	60,000	14,617	61,400	14,136
Springs	43,900	19,596	41,500	18,806
Sub Nigel	9,000	5,914	9,500	5,698
Transvaal G.M. Estates	15,620	£24,312§	15,590	£23,282‡
Van Ryn	32,500	£48,437†	32,200	£49,225
Van Ryn Deep	49,000	£136,246†	51,000	£144,526*
Village Deep	46,000	15,141	47,000	15,212
West Rand Consolidated	33,100	£48,411†	32,000	£48,802
Witw'ters'nd (Knights)	35,300	£48,442†	37,400	£53,995
Witwatersrand Deep	35,200	9,568	34,391	9,513
Wolhuter	31,400	7,970	32,600	7,842

* Gold at £5 7s. 6d. per oz. † £5 [illegible]s. 9d. per oz. ‡ £5 6s. per oz. § £5 1s. 3d. per oz.

Rhodesian Gold Outputs.

	May		June	
	Tons	Oz.	Tons	Oz.
Cam & Motor	11,200	£12,978†	11,700	[illegible]
Falcon	15,637	3,144*	15,572	[illegible]‖
Gaika	3,324	1,281	3,406	1,271
Globe & Phoenix	6,364	5,069	6,185	5,386
Jumbo	1,350	470	[illegible]	485
London & Rhodesian	—	£3,422	2,437	£3,051
Lonely Reef	5,440	5,396	5,350	5,280
Planet-Arcturus	5,820	2,942	5,700	2,438
Rezende	5,800	2,630	5,700	2,547
Rhodesia G.M. & I.	245	210	528	279
Shamva	55,500	£42,582‡	56,300	£43,946§
Transvaal & Rhodesian	1,600	[illegible]†	1,550	£5,063†

* Also 270 tons copper. † At par. ‡ Gold at £5 5s. per oz. ‖ Also 268 tons copper. § Gold at £5 10s. per oz.

West African Gold Outputs.

	May		June	
	Treated	Value	Treated	Value
	Tons	Oz.	Tons	Oz.
Abbontiakoon	6,864	£10,867*	6,550	£10,947*
Abosso	5,825	2,252	5,305	[illegible]
Akoko	—	—	—	—
Ashanti Goldfields	6,727	7,839	6,692	6,626
Obbuassi	1,018	£3,265†	839	£2,555†
Prestea Block A	7,312	£12,437*	7,177	£13,091*
Taquah	2,600	1,664	[illegible]	1,729†

* At par. † Including premium.

West Australian Gold Statistics.—Par Values.

	Reported for Export Oz.	Delivered to Mint Oz.	Total Oz.	Total Value £
October, 1920	174	53,801	53,975	229,275
November	128	54,729	54,857	232,017
December	321	53,595	53,916	229,057
January, 1921	523	50,934	51,457	218,574
February	684	26,872	27,556	117,050
March	10	47,875	47,885	203,401
April	607	46,602	47,209	200,635
May	474	47,638	51,503	217,495
June	153	28,194	28,347	120,410
July	1,641	44,917	46,558	197,774

Australian Gold Outputs.

	West Australia	Victoria	Queensland	New South Wales
1921	oz.	oz.	oz.	£
January .	51,458	4,587	4,582	20,463
February.	27,557	10,946	9,046	21,575
March ...	47,886	12,383	6,690	24,344
April	47,273	5,954	2,591	34,101
May	48,113	—	—	15,356
June.....	—	—	—	11,840
July	—	—	—	16,416
August...	—	—	—	—
September	—	—	—	—
October .	—	—	—	—
November	—	—	—	—
December	—	—	—	—
Total ..	222,287	33,865	22,909	144,095

Australasian Gold Outputs.

	May		June	
	Tons	Value £	Tons	Value £
Associated G.M. (W.A.)	6,023	7,285‖	5,962	7,658‖
Blackwater (N.Z.)	2,744	5,455*	2,927	6,290*
Bullfinch (W.A.)	—	—	—	—
Gold'n Horseshoe (W.A)	4,032	2,454‡	10,032	5,253‡
Grt Boulder Pro. (W.A.)	4,156	12,883‖	8,743	27,322‖
Ivanhoe (W.A.)	4,483	1,531‡	15,425	5,958‡
Kalgurli (W.A.)	4,958	11,250‖	1,572	4,371‖
Lake View & Star (W.A.)	4,012	10,274†‖	6,360	15,225†‖
Menzies Con. (W.A.) ..	—	—	2,070	4,309*
Mount Boppy (N.S.W.)	4,874	835‡	2,166	580‡
Oroya Links (W.A.) ...	1,548	7,418†‖	1,597	7,429†‖
Progress (N.Z.)........	—	—	—	—
Sons of Gwalia (W.A.) .	—	—	—	—
South Kalgurli (W.A.) .	—	—	11,364	18,663‖
Waihi (N.Z.)..........	11,959	3,511‡ 25,738§	13,762	4,004‡ 36,093§
,, Grand Junc'n (N.Z.)	6,020	1,790‡ 6,089§	5,700	1,730‡ 5,792§
Yuanmi (W.A.)	1,622	5,511*	1,666	4,513*

* Including premium; † Including royalties; ‡ Oz. gold; § Oz. silver; ‖ At par.

Miscellaneous Gold and Silver Outputs.

	May		June	
	Tons	Value £	Tons	Value £
Brit. Plat. & Gold (C'lbia)	—	282§	—	369§
El Oro (Mexico)	34,500	207,000†	34,500	209,000†
Esperanza (Mexico)	—	2,188†‡	—	329†‡
Frontino & Bolivia (C'lbia)	2,340	8,777	2,340	10,737*
Mexico El Oro (Mexico)..	11,500	184,780†	11,510	182,070†
Mining Corp. of Canada .	—	—	—	—
Oriental Cons. (Korea) ...	—	94,000†	—	94,000†
Ouro Preto (Brazil)	6,700	2,410‖	6,400	2,409‖
Plym'th Cons. (Calif'rnia	8,600	8,900	8,000	8,120
St. John del Rey (Brazil).	—	38,000	—	40,000*
Santa Gertrudis (Mexico)	37,258	10,742‡	36,602	14,298‡
Tolima (Colombia)	55**	—	—	—
Tomboy (Colorado)	19,000	65,000†	18,500	58,000†

* At par. † U.S. Dollars. ‡ Profit, gold and silver. ‖ Oz. gold. § Oz. platinum and gold. ** Production of silver ore.

Nechi (Colombia): 18 days to July 1, $16,879 from 165,407 cu. yd.; 18 days to July 19, $12,606 from 169,247 cu. yd.

Pato (Colombia): 16 days to July 9, $14,936 from 71,482 cu. yd.; 16 days to July 25, $14,507 from 70,080 cu. yd.

Indian Gold Outputs.

	May.		June.	
	Tons Treated	Fine Ounces	Tons Treated	Fine Ounces
Balaghat	3,300	2,609	3,200	2,342
Champion Reef	12,215	4,561	11,988	4,667
Mysore...............	16,818	10,776	17,243	10,506
North Anantapur	700	913	700	913
Nundydroog	8,630	5,315	8,916	5,304
Ooregum	12,900	8,482	12,900	8,475

Production of Gold in India.

	1917	1918	1919	1920	1921
	Oz.	Oz.	Oz.	Oz.	Oz.
January	44,718	41,420	38,184	39,073	34,028
February ...	42,566	40,787	36,384	38,872	32,529
March	44,617	41,719	38,317	38,760	32,576
April	43,726	41,504	38,248	37,307	32,363
May........	42,901	40,889	38,608	38,191	32,656
June	42,924	41,264	38,359	37,864	32,207
July	42,273	40,229	36,549	37,129	—
August	42,591	40,496	37,850	37,375	—
September ..	43,207	40,088	36,813	35,497	—
October	43,041	39,472	37,138	35,023	—
November ..	42,915	36,984	39,628	34,522	—
December ..	44,883	40,149	42,643	34,919	—
Total ..	520,362	485,236	461,171	444,532	196,369

Base Metal Outputs.

		May	June
Arizona Copper	Short tons copper ..	—	—
British Broken Hill ...	Tons lead conc. ...	—	—
	Tons zinc conc.	—	—
	Tons carbonate ore	—	—
Broken Hill Prop......	Tons lead conc. ...	—	—
	Tons zinc conc.	—	—
Broken Hill South	Tons lead conc.	2,897	2,533
Burma Corporation....	Tons refined lead ..	2,781	2,323
	Oz. refined silver ..	353,003	266,893
Hampden Cloncurry ..	Tons copper	—	—
	Oz. gold	—	—
Mount Lyell	Tons copper	435	451
	Oz. silver	10,432	14,316
	Oz. gold	277	280
Mount Morgan	Tons Copper	—	—
	Oz. gold	—	—
North Broken Hill.....	Tons lead	—	—
	Oz. silver	—	—
Rhodesia Broken Hill	Tons lead	1,760	1,569
Sulphide Corporation ..	Tons lead conc. ...	1,906	3,222
	Tons zinc conc	3,093	5,320
Tanganyika	Tons copper	2,846	2,736
Zinc Corporation	Tons zinc conc......	9,745	9,315
	Tons lead conc. ...	811	865

Imports of Ores, Metals, etc., into United Kingdom.

		May	June
Coal	Tons	450,162	1,390,824
Iron Ore	Tons	15,696	34,209
Manganese Ore	Tons	21,518	8,334
Copper and Iron Pyrites	Tons	5,170	3,881
Copper Ore, Matte, and Prec.	Tons	291	1,373
Copper Metal	Tons	7,609	8,542
Tin Concentrate	Tons	1,051	2,174
Tin Metal.....................	Tons	1,205	965
Lead, Pig and Sheet	Tons	10,709	12,103
Zinc (Spelter)	Tons	2,206	2,593
Quicksilver	Lb.	7,865	385,528
Zinc Oxide....................	Tons	209	340
White Lead	Cwt.	2,885	4,323
Barytes, ground	Cwt.	6,987	12,187
Phosphate	Tons	14,704	13,875
Sulphur	Tons	—	5
Nitrate of Soda................	Cwt.	18,994	19,800
Petroleum			
Crude	Gallons	9,299,586	7,137,546
Lamp Oil	Gallons	9,034,974	16,939,260
Motor Spirit	Gallons	28,364,422	16,390,603
Lubricating Oil	Gallons	3,750,784	1,953,902
Gas Oil	Gallons	1,494,292	7,181,277
Fuel Oil	Gallons	47,952,217	54,321,777

Output of Tin Mining Companies.

In Tons of Concentrate.

	April	May	June
Nigeria:	Tons	Tons	Tons
Associated Nigerian	—	—	—
Bisichi	27	28	33
Bongwelli	—	—	—
Champion (Nigeria)	—	—	—
Dua	—	—	—
Ex-Lands	20		
Filani	2	2	3
Gold Coast Consolidated	-		
Gurum River	7	7	10
Jantar	—	22†	—
Jos	6	4	7
Kaduna	10	11	11½
Kaduna Prospectors	11	8¾	10
Kano	—		—
Keffi Consolidated	-	-	15
Lower Bisichi	4¼	3	
Lucky Chance	—	-	—
Minna	—	—	—
Mongu	36	32½	35
Naraguta	45	40	38
Naraguta Extended	8	8	20
Nigerian Consolidated	8	6½	9
N.N. Bauchi	41½	42	64
Offin River	—	—	—
Rayfield	30	—	31
Ropp	95	97	104
Rukuba	5	3	3
South Bukeru	20	10	16
Sybu	1¾	1¾	1½
Tin Fields	4	—	—
Yarde Kerri	13	11	9½
Federated Malay States:			
Chenderiang	—	—	69*
Gopeng	77½	83½	86½
Idris Hydraulic	21	19	13½
Ipoh	—	20	5½
Kamunting	—	—	82*
Kinta	36	35¾	35¼
Lahat	51	50¼	52
Malayan Tin	77	83	86¼
Pahang	230	248	240
Rambutan	15½	16	15
Sungei Besi	34	36	33
Tekka	31	36	36
Tekka-Taiping	11	10½	21½
Tronoh	22	21	26
Cornwall:			
East Pool	—	—	
Geevor	—	—	
South Crofty	—	—	
Other Countries:			
Aramayo Francke (Bolivia)	195	161	165
Berenguela (Bolivia)	27	28	28
Briseis (Tasmania)	8	6	9
Deebook Ronpibon (Siam)	28	33	32
Leeuwpoort (Transvaal)	—	—	—
Macreadry (Swaziland)	—	—	—
Renong (Siam)	72	107	91
Rooiberg Minerals (Transvaal)	50	50	55
Siamese Tin (Siam)	76	120	124
Tongkah Harbour (Siam)	43	54	98
Zaaiplaats (Transvaal)	—	13	10

* Three months. † Tributers.

Nigerian Tin Production.

In long tons of concentrate of unspecified content.

Note.—These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual outputs.

	1916	1917	1918	1919	1920	1921
	Tons	Tons	Tons	Tons	Tons	Tons
January	531	667	678	613	547	438
February	528	646	668	623	477	370
March	547	655	707	606	505	445
April	486	555	584	546	467	394
May	536	509	525	483	383	337
June	510	473	492	484	435	321
July	506	479	545	481	484	—
August	498	551	571	616	447	—
September	535	538	520	561	528	—
October	584	578	491	625	628	—
November	679	621	472	536	544	—
December	654	655	518	511	577	—
Total	6,594	6,927	6,771	6,685	6,022	2,305

Production of Tin in Federated Malay States.

Estimated at 70% of Concentrate shipped to Smelters. Long Tons.

	1917	1918	1919	1920	1921
	Tons	Tons	Tons	Tons	Tons
January	3,558	3,030	3,765	4,265	3,298
February	2,775	3,197	2,734	3,014	3,111
March	3,286	2,689	2,819	2,770	2,190
April	3,251	3,308	2,858	2,606	2,692
May	3,413	3,332	3,407	2,741	2,884
June	3,489	3,070	2,877	2,940	2,752
July	3,253	3,373	3,756	2,824	—
August	3,413	3,259	2,956	2,786	—
September	3,154	3,157	3,161	2,734	—
October	3,436	2,870	3,221	2,837	—
November	3,300	3,132	2,972	2,573	—
December	3,525	3,022	2,409	2,838	—
	39,833	37,370	36,935	34,928	16,927

Stocks of Tin.

Reported by A. Strauss & Co. Long Tons.

	May 31	June 30	July 31
Straits and Australian Spot	1,430	1,931	1,936
Ditto, Landing and in Transit	585	135	250
Other Standard, Spot and Landing	4,457	4,279	4,388
Straits, Afloat	1,505	1,210	1,355
Australian, Afloat	150	90	135
Banca in Holland	3,405	3,780	4,244
Ditto, Afloat	445	485	351
Billiton, Spot	644	528	423
Billiton, Afloat	30	159	38
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	475	585	305
Total Afloat for United States	2,595	1,225	3,906
Stock in America	2,046	2,546	2,521
Total	17,767	16,953	19,852

Shipments, Imports, Supply, and Consumption of Tin.

Reported by A. Strauss & Co. Long tons.

	May	June	July
Shipments from:			
Straits to U.K.	1,425	320	1,340
Straits to America	1,735	600	2,420
Straits to Continent	507	505	215
Straits to other places	200	350	325
Australia to U.K.	—	25	150
U.K. to America	490	200	975
Imports of Bolivian Tin into Europe	353	724	221
Supply:			
Straits	3,667	1,425	3,975
Australian	—	25	150
Billiton	150	273	55
Banca	1,180	1,170	1,284
Standard	394	263	1,228
Total	5,391	3,156	6,692
Consumption:			
U.K. Deliveries	1,000	1,361	1,224
Dutch „	398	388	321
American „	1,225	1,590	1,525
Straits, Banca & Billiton, Continental Ports, etc.	132	631	713
Total	2,755	3,970	3,793

Outputs Reported by Oil-producing Companies.

		May	June
Anglo-Egyptian	Tons	14,173	13,529
Anglo-United	Barrels	10,700	9,660
Apex Trinidad	Barrels	21,000	16,985
British Burmah	Barrels	70,212	69,020
Caltex	Barrels	102,720	—
Dacia Romana	Tons	294	—
Kern River	Barrels	94,250	91,157
Lobitos	Tons	8,086	8,845
Roumanian Consol	Tons	2,189	1,115
Santa Maria	Tons	9,600	1,228
Steaua Romana	Tons	19,150	—
Trinidad Leaseholds	Tons	13,550	11,300
United of Trinidad	Tons	3,768	3,402

Quotations of Oil Companies' Shares.

Denomination of Shares £1 unless otherwise noted.

	July 6, 1921			Aug. 5, 1921		
	£	s.	d.	£	s.	d.
Anglo-American	4	10	0	4	5	0
Anglo-Egyptian B	1	8	9	1	8	9
Anglo-Persian 1st Pref.	1	2	6	1	2	6
Anglo-United, Wyoming		5	0		3	9
Apex Trinidad	2	0	0	1	17	6
British Borneo (10s.)		13	9		12	6
British Burmah (8s.)	1	0	0		17	6
Burmah Oil	6	7	6	6	2	6
Caltex ($1)		4	3		4	6
Dacia Romano	1	0	0		17	6
Kern River, Cal. (10s.)		19	6		19	6
Lobitos, Peru	4	5	0	4	2	6
Mexican Eagle, Ord. ($5)	5	7	6	5	6	3
,, ,, Pref. ($5)	5	2	6	5	2	6
North Caucasian (10s.)		17	6		17	6
Phœnix, Roumania		11	9		9	6
Roumanian Consolidated		12	6		10	3
Royal Dutch (100 gulden)	42	10	0	43	0	0
Scottish American		7	0		3	0
Shell Transport, Ord.	5	11	3	5	2	6
,, ,, Pref. (£10)	8	10	0	8	10	0
Trinidad Central	3	15	0	3	11	3
Trinidad Leaseholds	2	10	0	2	5	0
United British of Trinidad		18	9		17	6
Ural Caspian		17	6		17	6
Uroz Oilfields (10s.)		8	9		6	6

Dividends Declared by Mining Companies.

Date	Company	Par Value of Shares	Amount of Dividend
July 25	Broken Hill Proprietary	£1	9d.
August 6	Deebook Dredging	£1	1s.*
July 21	Eastern Smelting	P. Or. £1	10% less tax.
July 9	Gaika Gold	£1	5% less tax.
July 25	Glynn's Lydenburg	£1	3¾%
July 22	Lake View & Star	4s.	6¼% less tax.
July 23	Mond Nickel	Or. £1 Pr. £1	1s. tax paid. 7% less tax.
July 11	Oriental Consolidated	$10	50 cts.
July 14	Oroville Dredging	£1	1s. less tax.
July 11	Tekka	£1	4½d. tax paid.
July 27	Tekka Taiping	£1	3d. less tax.

* Instalment of return of capital.

PRICES OF CHEMICALS. August 8.

These quotations are not absolute; they vary according to quantities required and contracts running.

		£	s.	d.
Acetic Acid, 40%	per cwt.	1	0	0
,, 80%	,,	2	0	0
,, Glacial	per ton	60	0	0
Alum	,,	16	0	0
Alumina, Sulphate	,,	14	10	0
Ammonia, Anhydrous	per lb.		2	2
,, 0·880 solution	per ton	30	0	0
,, Carbonate	per lb.			4
,, Chloride, grey	per ton	40	0	6
,, ,, pure	per cwt.	3	5	0
,, Nitrate	per ton	45	0	0
,, Phosphate	,,	70	0	0
,, Sulphate	,,	13	0	0
Antimony, Tartar Emetic	per lb.		2	0
,, Sulphide, Golden	,,		1	5
Arsenic, White	per ton	45	0	0
Barium Carbonate	,,	11	0	0
,, Chlorate	per lb.			11
,, Chloride	per ton	17	0	0
,, Sulphate	,,	8	0	0
Benzol, 90%	per gal.		3	0
Bisulphate of Carbon	per ton	56	0	0
Bleaching Powder, 35% Cl.	,,	18	0	0
,, Liquor, 7%	,,	7	0	0
Borax	,,	34	0	0
Boric Acid Crystals	,,	69	0	0
Calcium Chloride	,,	10	0	0
Carbolic Acid, crude 60%	per gal.		1	7
,, ,, crystallized, 40	per lb.			6¼
China Clay (at Runcorn)	per ton	4	10	0
Citric Acid	per lb.		2	5
Copper, Sulphate	per ton	30	0	0
Cyanide of Sodium, 100%	per lb.			11½
Hydrofluoric Acid	,,			7½
Iodine	per oz.		1	0
Iron, Nitrate	per ton	9	0	0
,, Sulphate	,,	4	0	0
Lead, Acetate, white	,,	45	0	0
,, Nitrate	,,	48	0	0
,, Oxide, Litharge	,,	32	0	0
,, White	,,	44	0	0
Lime, Acetate, brown	,,	8	0	0
,, ,, grey 80%	,,	11	0	0
Magnesite, Calcined	,,	21	0	0
Magnesium, Chloride	,,	15	0	0
,, Sulphate	,,	10	0	0
Methylated Spirit 64° Industrial	per gal.		5	3
Nitric Acid, 80° Tw.	per ton	31	0	0
Oxalic Acid	per lb.			0
Phosphoric Acid	per ton	50	0	9½
Potassium Bichromate	per lb.			10
,, Carbonate	per ton	26	0	0
,, Chlorate	per lb.			5
,, Chloride 80%	per ton	20	0	0
,, Hydrate (Caustic) 90%	,,	33	0	0
,, Nitrate	,,	55	0	0
,, Permanganate	per lb.		1	6
,, Prussiate, Yellow	,,		1	3
,, ,, Red	,,		2	3
,, Sulphate, 90%	per ton	18	0	0
Sodium Metal	per lb.		1	0
,, Acetate	per ton	26	0	4
,, Arsenate 45%	,,	44	0	0
,, Bicarbonate	,,	10	10	0
,, Bichromate	per lb.			7
,, Carbonate (Soda Ash)	per ton	15	0	0
,, ,, (Crystals)	,,	7	0	0
,, Chlorate	per lb.			4½
,, Hydrate, 76%	per ton	26	15	0
,, Hyposulphite	,,	16	0	0
,, Nitrate, 96%	,,	18	10	0
,, Phosphate	,,	22	0	0
,, Prussiate	per lb.			7
,, Silicate	per ton	11	15	0
,, Sulphate (Salt-cake)	,,	6	10	0
,, ,, (Glauber's Salts)	,,	6	0	0
,, Sulphide	,,	22	0	0
,, Sulphite	,,	12	10	0
Sulphur, Roll	,,	13	0	0
,, Flowers	,,	13	0	0
Sulphuric Acid, Fuming, 65%	,,	24	0	0
,, ,, free from Arsenic, 144°	,,	6	5	0
Superphosphate of Lime, 30%	,,	8	10	0
Tartaric Acid	per lb.		1	7
Turpentine	per cwt.	4	2	0
Tin Crystals	per lb.		1	5
Titanous Chloride	,,		1	0
Zinc Chloride	per ton	22	10	0
Zinc Oxide	,,	41	0	0
Zinc Sulphate	,,	17	0	0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS:	Aug. 6, 1920			Aug. 5, 1921		
	£	s.	d.	£	s.	d.
RAND:						
Brakpan	2	16	3	1	1	0
Central Mining (£8)	8	13	9	6	8	9
City & Suburban (£4)		6	0		3	0
City Deep	2	13	9	2	11	3
Consolidated Gold Fields	1	19	9		17	6
Consolidated Langlaagte		17	0		12	6
Consolidated Main Reef		14	0		10	6
Consolidated Mines Selection (10s.)	1	2	6		14	6
Crown Mines (10s.)	2	13	9	2	1	3
Daggafontein	1	5	0		5	0
Durban Roodepoort Deep		4	0		4	9
East Rand Proprietary		8	0		5	3
Ferreira Deep		8	3		8	6
Geduld	2	0	0	2	11	3
Geldenhuis Deep		6	6		5	0
Government Gold Mining Areas	4	7	6	4	3	9
Johannesburg Consolidated	1	9	3	1	5	0
Kleinfontein		7	6		6	0
Knight Central		4	3		4	3
Knight's Deep		7	3		15	0
Langlaagte Estate		15	0		14	6
Meyer & Charlton	4	17	6	4	11	3
Modderfontein [illegible]	3	13	3	3	15	0
Modderfontein B (5s.)	6	15	0	1	11	3*
Modderfontein Deep (5s.)	2	6	3	2	7	6
Modderfontein East	1	3	9		12	6
New State Areas	1	6	3	1	2	6
Nourse		10	6		8	6
Rand Mines (5s.)	2	18	9	2	7	6
Rand Selection Corporation	2	15	0	2	12	6
Randfontein Central		13	0		11	6
Robinson (£5)		9	0		10	0
Robinson Deep A (1s.)	1	1	3		8	9
Rose Deep		16	3		14	0
Simmer & Jack		3	9		2	6
Springs	2	1	3	2	0	0
Sub-Nigel		16	3		12	6
Union Corporation (12s. 6d.)		17	9		15	6
Van Ryn		17	0		11	9
Van Ryn Deep	4	5	0	3	15	0
Village Deep		10	9		9	6
West Springs		18	9		10	0
Witwatersrand (Knight's)		13	9		15	6
Witwatersrand Deep		9	0		8	6
Wolhuter		4	0		3	9
OTHER TRANSVAAL GOLD MINES:						
Glynn's Lydenburg		11	3		6	6
Sheba (5s.)		1	6		1	9
Transvaal Gold Mining Estates		10	0		7	6
DIAMONDS IN SOUTH AFRICA:						
De Beers Deferred (£2 10s.)	20	0	0	11	0	0
Jagersfontein	4	2	6	2	7	6
Premier Deferred (2s. 6d.)	10	10	0	5	0	0
RHODESIA:						
Cam & Motor		11	3		8	9
Chartered British South Africa		16	3		11	9
Falcon		9	0		4	3
Gaika		16	0		10	6
Globe & Phœnix (5s.)		15	3		14	0
Lonely Reef	3	0	0	2	5	0
Rezende	2	17	6	3	5	0
Shamva	1	17	6	1	12	6
Willoughby's (10s.)		5	9		4	0
WEST AFRICA:						
Abbontiakoon (10s.)		3	0		2	3
Abosso		10	6		8	0
Ashanti (4s.)		17	6		16	0
Prestea Block A		3	0		1	0
Taquah		15	0		9	0
WEST AUSTRALIA:						
Associated Gold Mines		2	0		2	9
Associated Northern Blocks		3	0		2	6
Bullfinch		3	6		1	0
Golden Horse-Shoe (£5)		16	3		12	6
Great Boulder Proprietary (2s.)		7	9		6	0
Great Fingall (10s.)		1	9		1	6
Hampton Properties		10	3		4	9
Ivanhoe (£5)	1	0	0		17	6
Kalgurli		13	9		11	3
Lake View Investment (10s.)		17	0		8	9
Sons of Gwalia		5	6		4	0
South Kalgurli (10s.)		6	6		7	3

GOLD, SILVER, cont.	Aug. 6, 1920			Aug. 5, 1921		
	£	s.	d.	£	s.	d.
OTHERS IN AUSTRALASIA:						
Blackwater, New Zealand		8	9		2	6
Consolidated G. F. of New Zealand		3	9		2	6
Mount Boppy, N.S.W. (10s.)		6	0		2	0
Progress, New Zealand		1	9		1	3
Waihi, New Zealand		[illegible]	6	1	0	0
Waihi Grand Junction, New Zealand	1	1	0		8	9
AMERICA:						
Buena Tierra, Mexico		10	0		2	6
Camp Bird, Colorado		12	6		4	3
El Oro, Mexico		12	6		9	0
Esperanza, Mexico		10	6		17	6
Frontino & Bolivia, Colombia		11	8		6	3
Le Roi No. 2 (£5), British Columbia		10	0		2	6
Mexico Mines of El Oro, Mexico	5	10	0	4	5	0
Nechi (Pref. 10s.), Colombia		8	9		5	3
Oroville Dredging, Colombia	1	3	3	1	3	9
Plymouth Consolidated, California		13	9		12	6
St. John del Rey, Brazil		16	0		13	6
Santa Gertrudis, Mexico	1	2	0		7	3
Tomboy, Colorado		7	6		5	0
RUSSIA:						
Lena Goldfields	1	0	0		8	9
Orsk Priority		10	0		5	0
INDIA:						
Balaghat (10s.)		8	6		8	0
Champion Reef (2s. 6d.)		2	9		1	0
Mysore (10s.)		13	0		11	3
North Anantapur		4	0		2	6
Nundydroog (10s.)		19	9		6	3
Ooregum (10s.)		13	9		12	0
COPPER:						
Arizona Copper (5s.), Arizona	2	6	3	1	7	6
Cape Copper (£2), Cape and India	1	5	0		12	6
Esperanza, Spain		5	0		5	0
Hampden Cloncurry, Queensland		12	6		5	0
Mason & Barry, Portugal	1	10	0	1	10	0
Messina (5s.), Transvaal		5	6		3	6
Mount Elliott (£5), Queensland	1	5	0		10	0
Mount Lyell, Tasmania	1	3	3		14	0
Mount Morgan, Queensland		18	3		12	6
Namaqua (£2), Cape Province	1	12	6		15	0
Rio Tinto (£5), Spain	37	0	0	30	10	0
Russo-Asiatic Consd., Russia		10	3		11	3
Sissert, Russia		11	3		7	6
Spassky, Russia	1	1	3		11	3
Tanganyika, Congo and Rhodesia	1	16	3	1	0	0
LEAD-ZINC:						
BROKEN HILL:						
Amalgamated Zinc	1	7	6		17	6
British Broken Hill	1	17	6	1	0	0
Broken Hill Proprietary	3	1	3	2	0	0
Broken Hill Block 10 (£10)	1	3	9		12	6
Broken Hill North	2	11	3	1	11	3
Broken Hill South	2	10	0	1	7	6
Sulphide Corporation (15s.)		17	0		12	6
Zinc Corporation (10s.)		17	6		10	0
ASIA:						
Burma Corporation (10 rupees)	10	5	0		7	6†
Russian Mining		10	0		6	0
RHODESIA:						
Rhodesia Broken Hill (5s.)		11	0		6	3
TIN:						
Aramayo Francke, Bolivia	2	17	6	1	17	6
Bisichi (10s.), Nigeria		11	6		5	3
Briseis, Tasmania		4	3		2	6
Dolcoath, Cornwall		3	6			9
East Pool (5s.), Cornwall		13	0		3	9
Ex-Lands Nigeria (2s.), Nigeria		3	3		1	3
Geevor (10s.), Cornwall		12	6		3	9
Gopeng, Malay	1	17	6	1	12	6
Ipoh Dredging, Malay		14	3		11	3
Kamunting, Malay	2	10	0	1	5	0
Kinta, Malay	2	7	6	1	10	0
Malayan Tin Dredging, Malay	1	17	6	1	6	3
Mongu (10s.), Nigeria		17	6		11	3
Naraguta, Nigeria		10	0		16	3
N. N. Bauchi, Nigeria (10s.)		5	6		1	6
Pahang Consolidated (5s.), Malay		10	9		6	0
Rayfield, Nigeria		8	6		2	6
Renong Dredging, Siam	2	1	3	1	6	3
Ropp (4s.), Nigeria		8	3		5	6
Siamese Tin, Siam	3	2	6	1	15	0
South Crofty (5s.), Cornwall		13	9		4	0
Tehidy Minerals, Cornwall		17	6		6	3
Tekka, Malay	1	1	3		17	6
Tekka-Taiping, Malay	1	5	0	1	1	3
Tronoh, Malay	1	17	6	1	3	9

* New Shares. † 10-rupee shares of Indian Co.

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also notices of new books and pamphlets, lists of patents on mining and metallurgical subjects, and abstracts of the yearly reports of mining companies.

GEOLOGY OF PACHUCA AND EL ORO

At the February meeting of the American Institute of Mining and Metallurgical Engineers, Horace V. Winchell presented a paper giving some of his impressions of the geology of the Pachuca silver district, and the El Oro gold district, Mexico, obtained during a visit a year ago. His hints as to future work are of considerable practical value, and will be of interest to shareholders in the various companies at El Oro and in the Santa Gertrudis.

Pachuca.—Pachuca district is believed to have been discovered in 1522, and its present output is nearly one-sixth of the silver production of the world. The district consists of a series of mountains and valleys, the minor features of which extend in an easterly and westerly direction and reach elevations of 8,000 to 10,000 ft. above the sea. The range as a whole constitutes a continental divide; its axis runs northerly and southerly and separates the waters that flow westerly into the Pacific Ocean from those flowing easterly into the Gulf of Mexico. On the north and east the surface falls rapidly to the warmer zone, and is cut by deep canyons. In this warm country about 4,000 ft. below the summit is a canyon 2,500 or 3,000 ft. deeper that drains the region on the eastern slopes. Dense forests, heavy undergrowth, and much soil cover the land. On the western slope there is a different atmosphere and country; the vegetation is relatively sparse and the conditions semi-arid. The rocks are either bare or covered with laterite; they are often weathered and rotted to a considerable depth. According to the best weather data obtainable, there is a marked difference in the amount of rainfall on the two slopes, within the few miles occupied by the operating mines, on the north and east the rainfall being far greater than on the west. These conditions suggest a difference in the chemical activity of surface waters, which seem to have played an important part in the genesis of these extensive ore concentrations.

Tertiary eruptives similar to those that contain so many of the mines of Mexico and the south-western part of the United States are conspicuous features of the geology. The underlying basement on which these volcanoes were deposited is probably Cretaceous sediments, but none was observed in the area covered by these notes. The oldest rock seen is the older andesite. This is a thick flow of inconstant texture, and varies from a massive rock with few phenocrysts to a highly porphyritic mass in which are many whitened felspars and some altered pyroxenes with occasional biotites. Toward the north and west this typical andesite is succeeded by a quartz andesite, or dacite, much more siliceous, lighter in colour and with many quartz phenocrysts ranging in size from $\frac{1}{32}$ to $\frac{1}{8}$ in. in diameter. Whether the dacite is a phase of the older andesite or a separate flow was not ascertained. No definite line of contact was seen. Both of these rocks contain fragments of darker fine-grained andesite, and both at times exhibit marked flow structure. They can hardly have been intrusives, for there is no remnant of any covering rock. Moreover, at times the vesicular or amygdaloidal texture characteristic of rocks cooled near the surface is found.

The older andesite appears on the surface over the greater portion of the area thus far developed by mining operations. It can be traced continuously from a point more than 1 mile east of the Guerrero mill of the Real del Monte Co. to a point west of the Bordo shaft, where it passes beneath later eruptives, about 12 miles. Its width on the surface is much less, since its northern margin is south of the northern limit of underground mining operations, and may be seen just north of the valley in which are situated the Paraiso and Santo Tomas shafts. Its southern limit of exposure was not traced. Within this older andesite are east-west zones of extensive and profound thermal alteration in which the rocks have been altered over areas probably several miles long and often hundreds of feet wide. The altered rock is softer and lighter in colour than the fresh andesite, and carries occasional pyrite crystals, with calcite films and veinlets, and even quartz incrustations. It is in these altered zones in the older andesite (and dacite) that the important ore deposits have been found and developed.

The succeeding rock is later andesite. This consists of flows, breccias, and tuffs, all highly porphyritic and generally less massive than the older andesite. It is, however, sometimes thick-bedded and dense and so similar in appearance as to be distinguished with difficulty except on weathered surfaces. It weathers in various colours from reddish brown to bluish or purplish grey and covers large areas north of the actively mined district. In places, only a thin shell of this rock is left; elsewhere shafts go down through it into the lower andesite. In the Girault tunnel, the contact is well exposed; near the Trompillo shaft there is a steep fault contact between the two formations with the Vizcaina vein lying between. This later andesite has not been considered promising ground for exploration, and has produced but little ore. Whether this prejudice is based on its actual poverty or not is a question that can be answered only by future and deeper development, where this later formation attains great thickness. So far as the author could learn, the only workings in it are comparatively shallow (at least in the central portion of the district), and do not attain depths where, even in the older andesite, valuable ore-bodies are first encountered.

Still younger, and overlying the later andesite, is rhyolite. This rock is cream coloured and occurs on the surface in thin flows and tuffs, often much weathered and cut by small arroyos. Rhyolite or quartz-porphyry dykes of the same material are also seen on the surface and underground throughout the district from the Santa Gertrudis north to

the Capula and from the crest of the main divide above Real del Monte west to and beyond the Bordo. These dykes have various strikes and dips, but the large and more continuous ones strike and dip parallel to the main productive vein systems. On the surface and underground these rhyolite flows and quartz-porphyry dykes are cut by the vein fissures, which are sometimes particularly well mineralized and contain large stopes where they abut against or rest upon the dykes. At Capula the vein, carrying ore in two or more strands, is in a quartz-porphyry dyke of great longitudinal extent and from 50 to 100 ft. thick, dipping southerly about 50°.

Cutting later andesite, but of undetermined age relation to the rhyolite is basalt. This rock is seen in east-west dykes from 5 to 40 ft. thick, and a general northerly dip in the country west of the Pachuca mineralized area. It is not much weathered. It stands up in bold outcrops, and is dense and tough and contains abundant olivine phenocrysts. The later andesite near these dykes has been weathered and oxidized, and the red belts have sometimes been mistaken for veins.

So far as could be observed, all the veins of the Pachuca district belong to the same general period of fracturing. Although some veins terminate against or are faulted by others, the evidence tends to show that all of the productive veins thus far developed were formed and primarily mineralized at one period, and from the same agencies and structural disturbances. Nevertheless, there are two systems of veins; one striking east and west, and one striking north and south. The east-west veins are said to have been first discovered and worked, although the north-south veins, which are rich and wonderfully productive, have also been worked for many years. The latter occur in the eastern part of the district, largely in the property of the Real del Monte Co. Most of the east-west veins have numerous branches extending both north-easterly and north-westerly, forming what has been termed "linked vein" structure, quite typical of rock fracturing on a large scale. Some of the branches extend throughout the intervening space between the stronger east-west veins; others apparently die out before reaching any great distance. The full extent of the north-south vein system has not yet been disclosed, nor is it known how many such veins remain to be discovered. They seem to terminate on the south against the great Vizcaina fissure, although the Dios te Guie is said to be displaced by the Vizcaina and to extend a short distance south of it, without, however, containing much ore.

The principal veins of the east-west system are the Santa Gertrudis, Fresnillo, Anàlcos, Vizcaina, Maravillas, Santa Ana, and Polo Norte. La Corteza and El Lobo veins strike north-westerly, while the Veta del Tajo, Cristobal Colon, and Florencia strike to the north-east.

So far as developed, the north-south veins, in their order from west to east, are the Dios te Guie, San Sabas, Purisima, Santa Ines, Santa Brigida, and Veta de la Reina. The stoping width of these veins varies from 3 to 40 ft., and some of the ore-shoots, such as that in the Purisima (N-S) vein, are 400 metres long. The large east-west veins contain some of the longest ore-shoots ever developed, reaching 1,000 metres in the Santa Gertrudis vein and as much in the Vizcaina. The horizontal dimensions of the ore-shoots generally exceed the dip-length. The bearing of this fact on the question of ore genesis will be suggested later. The dip of the east-west veins is generally to the south, at angles of from 65° to 80°. Local north dips are not uncommon. The north-south veins dip both easterly and westerly; it is said that the former are the more productive.

The veins occupy planes of fracture and zones of shearing and are composed of crushed country rock more or less completely replaced by quartz and other vein minerals. The best veins, from the standpoint of productivity, are in and course through the zones of greatest rock alteration, and yet there was occasionally observed a belt or barrier of fresher looking rock just before coming to a vein. Such a belt lies just east of the east-dipping, north-south Purisima vein.

There are evidences of two generations of quartz deposition. The first period quartz, which replaced the broken andesite and often presents a banded or curved structure suggestive of its deposition around rock fragments, is white and bony or ivory-like. Upon and around this white quartz and in its interstices is a darker later quartz carrying silver minerals with pyrite and a little galena and, still rarer, crystals of blende and chalcopyrite. Where not replaced by quartz, the vein filling is sericitic or kaolinic. The quartz is usually broken into fragments, especially where the veins are wide, but is sometimes solid and "frozen" to the hard country rock. Some veins have good walls; some are in "bad ground", some are accompanied by well-defined planes of movement on one or both walls or in the veins themselves. The best and most abundant ore seems to be in those veins that are quite open to the passage of ground water. There is not a great flow of water, considering the length of underground development. As the rainfall at Pachuca is so much less than that at Real del Monte, it is probable the eastern mines make more water than those in the western camp.

It is a singular and significant fact that on the western slope oxidation extends to the lowest productive levels, about 2,000 ft. from the surface. This is not intended to imply that no sulphide minerals remain. The sulphide of silver, argentite, is the principal ore-mineral, and pyrite is quite abundant; but the quartz is honeycombed, rhodonite and rhodochrosite are more or less altered to psilomelane and pyrolusite, horn silver is apparent, and calcite coatings are found on the joints and in cavities. The effect of weathering is naturally greater as one approaches the surface, and, indeed, not only the silver but the quartz itself seems to have been dissolved out of the upper portion of the veins and carried downwards. It is only occasionally that quartz and ore persist upwards to the grass roots. Few stopes extend high enough to make their presence known by surface settling, and the average prospector acquainted with the camp states without hesitation that good ore can hardly be expected short of 400 or 500 ft. in depth. This has a familiar sound, but seems to have more than an element of truth here. Long ore-shoots, already fully explored and mined upwards to their terminations sometimes have tongues projecting to the daylight; but the average line of the upper margin of the long shoots is perhaps 150 metres from the surface. Indeed, there seems to be a general parallelism between the surface topography and the configuration of the ore-shoots below. This rule may possibly not hold where there is a con-

siderable thickness of recent volcanics, even though such rocks are cut by the vein fissures. It must be admitted that there is no rule without exceptions and that no general statement is applicable to every vein in the district. There are stopes that reach the surface ; there are ore-shoots that do not persist downwards ; there are veins whose production has come from within 500 ft. of the present surface and others that are chiefly barren to that depth and productive below it. Nevertheless, there is a remarkably persistent general relation between the surface and the upper limit of the pay ore. This relation becomes still more striking when the termination of the ore downwards is considered. There seems to be little doubt in the minds of those familiar with Pachuca that the mineralization has a rather abrupt and very definite termination in several fully explored mines, and that the productive area of the veins is confined within a vertical range of about 2,000 ft. Moreover, in no one ore-shoot is the full extent of this zone mineralized. The average height of the pay-ore zone is, perhaps, 1,500 ft., in many cases less, and in a few cases more. It is a matter of common knowledge that the veins scatter, the quartz diminishes, the values fall off rapidly, and only occasionally are found any sulphide or base minerals such as blende and galena. This general situation is not in any way exceptional for veins in Tertiary eruptives, but the explanation may not always be the same nor the geological record so easily read.

In considering the possibilities of a mining district an understanding of its geology and something as to the probable genesis of its ores is valuable as a guide in explorations and in appraising its future. The facts given may be summarized as follows: (1) The country rock is a series of Tertiary volcanics. (2) The vein fissures cut the entire series from the oldest to the youngest. (3) parallel to the veins are quartz-porphyry dykes of considerable extent. These are not universally known, but are in sufficiently constant association with the veins to be taken into consideration as possible agents in ore genesis. (4) The country rock is not only widely sheared and fissured, but presents evidence of profound alteration by thermal waters over wide zones. (5) The country rock is still further altered by weathering from the surface down to considerable depth. (6) The veins are largely quartz, but this quartz seldom comes to the surface and never in such quantity as in the veins underground. This statement is true of veins and their outcrops, whether found on the crests of mountains or in deep valleys. In other words, both quartz and ore lie for the most part some distance below the surface. (7) Oxidation and leaching persist to the lowest levels of silver enrichment. Horn silver, native silver, and argentite (the last greatly predominating) are the ore minerals. They occur in white quartz, which is itself secondary, or as incrustations or cavity fillings, together with pyrite and an occasional speck of chalcopyrite and galena. For the most part oxides of iron and manganese are present, though in diminishing amount as depth is gained. (8) There are seldom any massive sulphide ore-bodies in the veins beneath the oxidized ore, nor are there in the upper levels the large masses of oxidized material that often indicate the former presence of heavy sulphide bodies. (9) The major axes of the ore-shoots are more nearly horizontal than vertical ; so much so that the Pachuca district is almost unique in this respect. (10) The vein quartz dies out downwards, and even large veins dwindle into a series of scattered and unmineralized stringers. (11) All the mineralized veins belong to one general period and contain the same kind of ore. The products of the district are silver and gold in the ratio of about 5 gm. of gold to 1 kg. of silver.

With reference now to the richly productive portion of the Pachuca camp, the history of ore formation may well have been somewhat as follows : Having accumulated in large mass, the andesites, both older and later, slowly cooled, and zones of shearing were produced by shrinkage and subsidence. Through the multitude of cracks and fissures vapours and hot waters penetrated the rock and effected widespread alteration, depositing at the same time barren pyrite in disseminated crystals over zones of considerable width. When these fissures extended to sufficient depth there was another outburst of magma, this time quartz-porphyry and rhyolite, followed by the usual period of hot-spring activity. At this time the first quartz was deposited in and along the fissure already formed and replacing and silicifying the broken andesite along the shear zones. The period of subsidence and fracturing was not yet at an end, for the quartz-porphyry itself, after cooling sufficiently, was fractured and fissured and somewhat mineralized. Then, with the dying down of fumarolic and hot-spring activity, came the opportunity for surface-waters, which up to this time had been operating solely on the exposed surfaces, to begin working their way downward along the fissures and shear zones, oxidizing and dissolving the scattered sulphides and carrying them to new resting places at lower levels. It is not known how much erosion has taken place since these Tertiary rocks were formed, but that it may well have been thousands of feet is shown by the depth of the valleys in the immediate vicinity. On the western slope of the mountains chemical changes are rapid, and with an already altered rock on which to operate the upper parts of the veins were constantly and successively oxidized, leached of quartz, silver minerals, pyrite, and gangue minerals, while the surface was eroded and carried away. Always the values were held in the veins and carried downward in advance of the dissipating forces of erosion, and times without number the little films of argentite that had been deposited at a safe depth and were becoming endangered by the slow approach of the surface, were removed still deeper. In this way there is the cumulative result, first, of ages of primary deposition, during which perhaps no commercial ore-bodies were formed, and, second, of a long period of weathering under a hot sun and climatic conditions distinctly favourable to secondary enrichment. The proof of the theory is in the character of the minerals, the leaching and other evidences of the work of descending waters, as well as the shape of the ore-shoots, their correspondence with the topography of the surface, the paucity of quartz at grass roots, and its diminuendo habit beneath the ore accumulations. In short, all the broad phenomena of the district seem to be in accord with this theory and with no other. It is supported by both the positive proof and the negative facts, by the minerals found as well as by those that are not present ; it is a most excellent example of the formation of large and deep ore-bodies by secondary sulphide enrichment.

Similar forces working on similar materials under similar conditions, for an equal length of time, may be expected to produce similar results. Thus, with equal precipitation and evaporation over the entire district, uniform surface gradients on both sides of the divide, and similar rocks uniformly sheared and fissured so as to offer equal receptivity to drainage, there would probably result a similarity in topography and in the subterranean products of weathering agencies. Where the materials are similar but the conditions are known to vary, it is reasonable to attribute heterogeneity of products to such variance of conditions ; and where the rocks are different, products may be formed by the operation of similar forces under similar conditions. At Pachuca, the rocks are, in general, similar mineralogically and structurally ; the operating forces are similar, although not of equal intensity nor volume ; the time factor is practically constant ; but the products have a wide variance in different portions of the district.

Reference has been made to the marked difference in the annual precipitation on the western and eastern slopes of the continental divide, but its effect has not been fully described. The first result to be noticed is in the different sculpturing of the surface. On the eastern slope the topography is rougher, the slope gradients are steeper, the changes in elevation more frequent and abrupt. On the western slope there are many long, smooth, gently sloping hillsides, and comparatively few sharp and deep canyons. As a consequence, the rainfall, if equal over the two areas, would run off faster on the eastern than on the western slope, and a smaller amount would percolate downward into the rocks. But with the much greater rainfall on the eastern slope, it might be expected that the effect of surface waters would be at least as great, and oxidation as deep in Real del Monte as in Pachuca. In fact, considering alone the much greater precipitation, one would expect deeper and more intense oxidation. But the reverse is the case. Sulphide minerals are rarely found within 300 ft. of the surface in the western part of the camp, while they are abundant within 70 ft. of the surface about 1 mile east of the Guerrero mill, on the eastern side of the range. It is probable, as already stated, that there is more water in the mines and in the ground generally on the eastern than on the western slope. The question arises, why, then, is there such a marked difference in the depth to which oxidation has extended ? No doubt many factors enter into the problem. It is evident at a glance that erosion is more rapid, and that it nearly keeps pace with oxidation, on the eastern slope. But there are other reasons why sulphides in that section are so much nearer the surface. It may be explained in part by the fact that the rain waters are not so active chemically after soaking through the soil. There is perhaps not enough difference in temperature to make any material difference, although such difference probably exists. It is perhaps more largely due to the fact that the rank vegetation that covers the eastern foot hills deprives the rain of its oxygen, and hence the underground waters in that section are comparatively inert. In this respect Pachuca offers a rare example of the effect of differing climatic conditions on the depth and character of mineralization in veins. In another respect, also, it is interesting. Many observers here and in other districts have noted the fact that there is oxidation below the present water table, and have attributed the phenomenon to a change of water-level in comparatively recent time. This does not appear to be the only, nor, indeed, always the more probable, explanation. Where, as is probably the case here, the entire volume of ground water is slowly moving downward, and yet is ever renewed by annual rainfall, there must be oxidizing action until all the oxygen is consumed, and thus even below the surface of the subterranean water-table, extending downwards perhaps several hundred feet, the sulphide minerals will become oxidized.

El Oro.—For his data on El Oro, the writer is indebted not alone to his personal examination, but to a report on the camp by Waldemar Lindgren, written in 1913. From this report are taken the following more general statements, in order to lay the foundation for points that seem to be of special interest to the economic geologist. The district of El Oro is situated on the high plateau of Mexico, near its western edge, at an elevation of about 10,000 ft. On this part of the plateau broad valleys are separated by irregular groups of mountains rising 2,000 to 3,000 ft. above the depressions. The valleys are filled with volcanic tuff and detritus. The mountains are largely built up of volcanic flows, mainly andesite, but at many places the underlying older rocks are exposed. The latter consist of calcareous shales of Cretaceous or Jurassic age, and in places contain an older series of igneous rocks intruded into the shales and exposed by erosion. The geological sequence is then as follows : (1) Calcareous shale with some sandstone and limestone. (2) Older Tertiary igneous rocks intruded into or poured out on these sedimentary shales. (3) Formation of fissure veins intersecting shales and older igneous rocks. (4) Epoch of erosion. (5) Late Tertiary and recent igneous rocks, chiefly flows of lava and tuffs, resting on eroded shales, older igneous rocks and veins, and showing no mineralization. (6) Recent epoch of erosion.

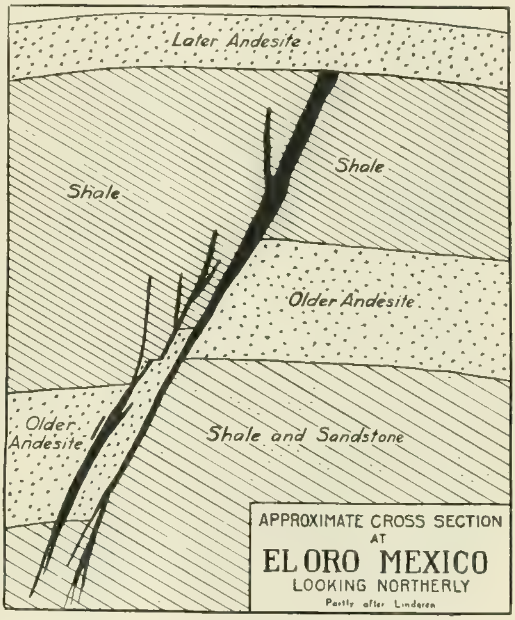
The younger surface lavas are mostly massive, dark-grey, hornblende-andesites, which are oxidized and disintegrated near the surface, but show no mineralization, nor do they contain pyrite. Toward the valley agglomerates and tuffs gradually take the place of the massive rocks. Where the contact with the shales is exposed by mining operations, a few feet of reddish stratified material of fragmental origin often rest directly on the shale. The thickness of this lava is manifestly affected by the recent erosion. Along the San Rafael lode, south of North shaft, it is less than 200 ft., but north of this point it increases to 400 ft., and at Tiro Hondo and San Patricio shafts it is about 600 ft. Under the summit of the hill the thickness is 1,000 ft. Dykes and intrusive necks of this lava are found in the adjoining Esperanza mine.

The older andesite is a greenish dense rock, which has been greatly altered by the vein-forming agencies and now contains much pyrite, calcite, and sericite. It occurs as thick intrusive sheets, or as irregular masses in the black shales, also as smaller dykes. On the property of the El Oro Co. none of this rock reaches the present surface or the old surface underneath the younger andesite, but it forms a thick flat body which is about 600 ft. thick ; it was first encountered in the northern part of the property along the San Rafael vein, about 600 ft. below the capping. Farther south, it lies deeper, being near the interior shaft at about 900 ft. below the capping ; and in the Carmen mine

its top lies again about 800 ft. below that surface. The lower contact with the shales has been found in the northern part of the mine. Throughout, this andesite sheet, or sill, is faulted by the fissure of the San Rafael, the vertical throw being, in the vicinity of the Somera shaft, about 670 ft. Down to about the 1,300 ft. level, the andesite appears only in the foot-wall. Below the 1,300 ft. level, it begins to appear in the hanging wall, and continues to form that wall down to the 1,600 ft. level, the lowest point reached. (Since Lindgren's examination the mine workings have developed ground far beneath the lower margin of this sill.) The older series of andesite is represented both by intrusive rocks and lava flows.

The predominating sedimentary rock is a black, bituminous shale, well stratified and often containing much calcite, in fact, grading into a calcareous shale and occasionally into a black granular limestone. In places the shale contains embedded masses of a dark-grey friable sandstone. This sandstone is more abundant in the deep levels, and is typically present at the station and cross-cut of the Somera shaft on the 1,300 ft. level. When examined in the field, this rock was held to be of tuffaceous origin, but the microscope has shown it to be a pure quartzose sandstone. The sedimentary rocks lie horizontal, or at slight dips that exhibit no marked irregularity. A total thickness of 1,300 ft. of strata is exposed in the workings.

Mr. Winchell proceeds as follows: We have at El Oro a series of veins bearing gold and silver minerals in a quartz-calcite gangue. These veins are fissures that were filled by replacement and infiltration. Some of them are evidently fissures of considerable displacement. They cut through the black shales and through the sill of andesite that was intruded horizontally into these shales, and which, as a natural consequence, is both overlain and underlain by the shale beds. After the veins were formed and mineralized, they were subjected to the action of surface waters for a considerable time, and an unknown extent of their upper portions was removed by erosion. They are oxidized to the depth of nearly 1,000 ft., and their silver content at least was secondarily enriched by the action of descending waters. The general strike of the veins is about N. 30° W., and their dip at varying angles to the west. They have branches in both foot and hanging walls, but more numerously in the latter. After a long period of weathering and erosion the country was covered by more recent lava flows, which were in turn weathered and eroded until in some localities the underlying shales and one vein, the first discovered Descubridora, are exposed on the surface. These lava flows and volcanic tuffs are not penetrated by the veins which cut the underlying rocks. The veins are, in turn, cut and displaced by north-dipping east-west faults. These faults are unmineralized, except by a little calcite, which may be of recent deposition. Their general effect has been to step the country down to the north. The direction of movement along several of these faults has been diagonally downwards to the east. The andesite sill varies in thickness from 400 ft. to possibly more than 700 ft.; it has been cut and displaced by the vein fissures with throws of several hundred feet. The most productive ore-bodies have been found in the veins where they lie within the shale overlying the andesite sill and adjacent to it, where, by reason of faulting movement along the vein fissures, the shale is brought in opposition to the andesite. There is also some ore found where the veins lie wholly in andesite, but not in large quantity anywhere above the lower margin of the lower faulted segment of the sill. Developments indicate that the veins are not enriched for any distance below the andesite. Quartz, indeed, is found to persist for some distance beneath it, but with diminishing tendency downward, and with smaller ore-shoots. The quartz scatters in stringers of diminishing strength, and dies out. The lower stretches of the veins contain some of the baser sulphides, such as blende and galena. The commercial ore-bodies occur in long relatively horizontal ore-shoots better mineralized in the upper levels. Some of these shoots have been definitely bottomed while others are still being pursued through their downward reaching lobes and tails.



APPROXIMATE CROSS SECTION AT EL ORO MEXICO LOOKING NORTHERLY
Partly after Lindgren

It is seldom in the course of geological study that the facts observable suffice to point strongly to a particular mass of eruptive rock as the source of vein mineralization. In this respect El Oro is of particular interest. The position of the ore-bodies in the ground and their relation to the andesite sill, the dwindling of the quartz and mineralization downward suggest that it was the fountain head of ore-deposition. There is nothing to suggest the presence of other sills or masses of intrusive rock, and many facts that lead one to doubt their existence. This holds true of all the veins thus far developed. They are large and rich above the sill and poor and small or entirely pinched out beneath it. This could hardly be the case if they had been formed from solutions rising from greater depth. This theory is useful as a working hypothesis, for it not only suggests the futility of costly exploration beneath the sill, but at once shows the attractiveness of territory overlying the sill still unexplored and now covered by later andesite, which caps the vein-carrying shale.

REMOVAL OF COPPER FROM BASE LEAD BULLION

The *Proceedings* of the Australasian Institute of Mining and Metallurgy, No. 38, 1920, contains a paper by D. C. M'Garner entitled: The Treatment of the Copper Impurity in the Lead Ores Smelted by the Sulphide Corporation, at Cockle Creek, New South Wales. The question of dealing with the small quantities of copper found in a great many of the purchased ores became a factor of importance when the Sulphide Corporation decided to refine its own lead bullion, as the presence of this impurity has a marked effect on the efficiency of the desilverizing operations of the Parkes process.

The copper is removed from the base bullion by drossing, which collects the copper, and at the same time has considerable gold, silver, and lead values. The drossing of the bullion is done in two stages: firstly, at the smelters; and secondly, in the copper kettles at the refinery. In both cases a wet dross is produced, which is subsequently sweated in a suitable type of furnace. When dry the dross is raked out and stored until enough accumulates to warrant a run on dross in the small blast-furnace kept for that purpose. A typical assay of the dry dross is as follows: Au, 0·3 oz. per ton; Ag, 55 oz. per ton; Pb, 60–70%; Cu, 6·5%; Fe, 2·2%; Zn, 1·5%; Sb, 4·5%; As, 1·6%; S, 4·5%. The accumulated dross is treated in a small blast-furnace with the necessary fluxes, producing a low-grade Cu–Pb matte and base lead bullion. The assay-value of the matte is approximately as follows: Au, 0·05 oz. per ton; Ag, 30 oz. per ton; Pb, 23·2%; Cu, 23–25%; Fe, 25%; Zn, 3·0%; Sb, 5·6%; As, 3·3%; S, 14·4%.

This matte was formerly crushed, roasted, leached with H_2SO_4, and copper precipitates produced; but owing to the shortage of scrap iron some other means of converting the copper into a marketable form had to be sought. The conversion to bluestone showed most promise, and with this object in view the low-grade matte is crushed through ¼ in. screen, given a quick roast in the rotary furnaces, then over a Dwight-Lloyd machine, and finally worked up to high-grade matte in a reverberatory furnace. In working the low-grade up to high-grade matte, the time of treatment is gauged by the Fe contents of the charge, and when a dip sample shows the Fe to be about 2% the charge is tapped, irrespective of the copper values. The lead loss is naturally high, but provision is being made to connect the reverberatory furnace to a bag-house in the near future. An average assay of the high-grade matte produced is as follows: Au, 1·125 oz. per ton; Ag, 69 oz. per ton; Pb, 24%; Cu, 47%; Fe, 2%; Zn, 2·4%; S, 17%. The high-grade matte is crushed in a Krupp mill through 40 mesh screen, roasted in a 4-hearth hand reverberatory furnace, and then passed on to the leaching department for the production of bluestone. The temperature aimed at when roasting is between 600° and 625° C, the following tests being taken under working conditions: No. 1 hearth, 460° C; No. 2 hearth, 532° C; No. 3 hearth, 582° C; No. 4 hearth, 618° C. An average sulphur assay of the roasted product is as follows: Total S, 7·7%; S as SO_4, 7·4%.

The copper is dissolved out of the matte by leaching with dilute H_2SO_4 in an ordinary circular agitation vat provided with a wooden paddle, which is driven by a spur and pinion wheel fitted over the top of the vat. Two such agitators are in use, and they are employed for either leaching the roasted matte or purifying the neutral leach liquors. Sometimes one is treating matte and the other is purifying liquors, and at other times they are both purifying accumulated neutral liquors. The production of a neutral impure liquor occupies from 1 to 5 hours, whereas 5 to 15 hours are necessary for purification, according to the quantity of iron present; therefore an accumulation of impure neutral liquor takes place. In making up neutral liquors, the roasted high-grade matte is carefully weighed, then tipped into the agitator, which has been previously filled to the correct level with H_2O (or acid wash liquors from a previous charge) and a calculated quantity of H_2SO_4. Sufficient acid is added to give a neutral liquor containing 70 to 80 grm. per litre of copper. The temperature of the liquor is kept up to about 70° C by means of live steam delivered to the bottom of the agitator. Samples are taken during the agitation, and a test made for Cu, Fe, and free H_2SO_4. When the copper in the solution is correct, and the acid neutralized, the agitation is stopped, the steam turned off, and the pulp allowed to settle, the clear liquor then being syphoned off to the storage vat for impure neutral liquors. It has been found that at least three leaches can be made before it is necessary to discharge any residues. The copper content of the matte, of course, controls the size of the charge to the agitators, and consequently the number of charges treated before discharging a residue.

After the third neutral liquor has been syphoned off, two successive acid washes are given to the residues. Each wash is given about 2 hours' agitation with 5 to 10% H_2SO_4. Live steam is used to raise the temperature to about 60° C. Periodical tests of the wash liquor for copper and acid are taken, and, when no further increase of copper in the solution is shown, the agitation is stopped, the pulp is allowed to settle, and the clear acid-wash liquor is run off to the wash-water storage vat. From the vat it is subsequently pumped back to the agitator for the next charge to make up neutral leach liquors of the required strength. After the second acid wash has been settled and run off, sufficient water is added to flush the whole of the residues out of the agitator through a bottom discharge into No. 1 of three cone-shaped settling vats, which are terraced to flow from No. 1 to No. 2, and so on, finally overflowing into the storage vat for acid-wash liquors. These vats allow the pulp to settle, and the clear wash water, which contains a little copper, is either displaced by running in fresh water to No. 1 or by syphoning off to the acid-wash storage vat. The thickened pulp is discharged through a bottom discharge pipe into a large brick bin, where it is allowed to dry out sufficiently to be sent to the roasting department. All bluestone plant residues, which represent about 40% by weight of the original high-grade matte leached, are incorporated in the Huntington-Heberlein pot charge, which forms part of the ordinary daily charge to the blast-furnace. Of the metal values in the high-grade matte treated, all of the Au, Ag, and Pb is retained in the residues, together with 46% of the Fe, 32% of the Zn, and 9·5% of the Cu. The Au, Ag, and Pb values are thus separated from 90·5% of the copper, and are subsequently recovered with the bullion produced

in the blast-furnace, the copper that escaped solution being again drossed off.

Iron is the chief removable impurity, and during its precipitation the whole of the As and Sb is also precipitated. The Hofmann system of purification has been successfully employed. This system claims that in the presence of air and CuO (in hot liquors) ferric sulphate is oxidized, then precipitated as ferric oxide, and that a chemical equivalent of copper goes into solution as $CuSO_4$. A considerable departure from the somewhat elaborate purifier, as described by Hofmann, has been made, and all liquor purifications are carried out in an ordinary agitation vat. Several methods of applying the air have been tried, but the best results have been obtained by delivering the air and steam at a point near the bottom of the agitator, either by two independent lead pipes of equal length strapped together—one for air and the other for steam—or by mixing the air and steam in one lead pipe. Whichever method is applied, the lead pipe is securely fixed to the inside of the agitator by means of wooden cleats.

The agitator is filled to the correct level with impure neutral leach solution. A sample of the liquor is taken and tested for iron in the ferrous state, the agitator is then started, and steam and air turned on. For the necessary CuO either ordinary roasted high-grade matte or roasted copper precipitates are used, and, as the temperature rises in the agitator, about 300 lb. of roasted matte or precipitates are tipped in. The progress of the purification is carefully watched by means of a sample of the liquor taken every hour, and a test made for ferrous iron by acidifying the sample with H_2SO_4 and titrating direct with standard $KMnO_4$. In the presence of the added CuO (in the roasted matte or precipitates) no appreciable iron in the ferric state is found in the solution; therefore a titration for Fe in the ferrous state gives a true working indication of the total iron in the solution at any stage of the purification. The amount of Fe in the impure neutral liquors varies considerably, according to the iron in the matte treated and the completeness of the roasting. The maximum Fe found in the impure leach liquors is about 10 grammes per litre, and the minimum about 2·0 to 2·5 g.p.l. The degree of purification aimed at is from 0·15 to 0·2 g.p.l. Fe. From 5 to 15 hours' agitation and aeration are necessary, and, when the purification is finished, the agitator is stopped, steam and air turned off, and the charge allowed to settle. The clear solution is then syphoned off to the storage vat for purified liquors. The following tabulation shows the completeness of the removal of Fe, As, and Sb, the Zn not being affected :—

	Cu	Fe	As	Sb	Zn
Impure liquor (g.p.l.)	73	5·1	1·05	trace	3·0
Purified liquor (g.p.l.)	80	0·15	trace	nil	3·1

After decanting the purified liquor, the residue, which contains a considerable bulk of precipitated ferric oxides, is given a weak acid wash to dissolve the unconverted CuO. About three hours' agitation is given. The residue is allowed to settle, and the liquor decanted to the acid-wash liquor storage vat. If necessary two acid washes are given, then the residues are discharged, with water, in exactly the same manner as ordinary leach residues when making up neutral impure liquors. All acid-wash water is used as subsequent leach solutions for fresh charges of impure liquor.

The main evaporating pan is a rectangular lead-lined wooden vat of 750 gallon capacity. The first arrangement consisted of six 4 in. lead-covered boiler tubes let into the vat longitudinally, with a fire-box, suitable for burning coke, at one end, and a chimney at the other. The rate of evaporation proved to be altogether too slow, and the coke consumption was abnormal. Steam coils were then installed, the first being a 1 in. soft-lead piping. The best results have, however, been obtained by using 1½ in. Sb–Pb piping, containing 4% Sb. On account of the strength of the hard-lead piping the scale can be periodically removed without injury to the coil. A percentage analysis of the scale that forms is as follows: Pb, nil; Cu, 28·8; Fe, 0·4; Zn, 0·9; Sb, trace; As, 0·9; total S, 14·5; S as SO_3, 14·5. The evaporator will not hold enough concentrated liquor to fill a crystallizing vat, therefore when the liquor in the evaporator has attained a specific gravity of 1·4 it is run to a storage vat provided with lead coil, using the waste steam from the evaporator. This storage vat acts as a further concentrator, and also as a means for thoroughly clarifying the liquor before its gravitation to the crystallizers, where it is delivered at from 1·42 to 1·43 sp. gr. and from 80° to 85° C.

The crystallizing vats in use are made of brick, lined on the sides with 8 lb. sheet lead, and with 10 lb. lead on the bottoms. The dimensions of the vats are 8 ft. by 10 ft. by 2 ft. 9 in. high, and their capacity 1,370 gallons. To give the maximum of surface for bluestone crystals to build upon, each vat has 112 sheet-lead strips 8 in. wide and 4 ft. 3 in. long, hung on 4 in. by 2 in. hardwood battens, and allowed to extend down into the vat to within about 7 in. of the bottom. When it is desired to fill a crystallizer, all the strips are placed in position; the hot concentrated liquor is gravitated from the storage vat, covered over with hessian, and allowed to cool slowly for from 7 to 9 days. From 2 to 2·5 tons of dried bluestone are made per charge. When the crystallizer is to be emptied, the mother liquor is ejected by means of a steam ejector. The crystals are all knocked off the strips and sides on to the bottom of the vat, then shovelled out and delivered to the washer. Thus two products are obtained from the crystallizing vats: (1) Mother liquor; (2) bluestone crystals.

An average analysis of the mother liquor is as follows in terms of grammes per litre: Cu, 84; Fe, 0·8 to 2·0; Zn, 11; Free H_2SO_4, 1·8; Sp. gr., 1·26. The original procedure was to further concentrate the mother liquor and produce a second crop of bluestone, but it was found that the resulting crystals were of low grade, which necessitated their being dissolved and re-crystallized. The assay-value of the low-grade bluestone thus produced was: Cu, 24·95%; $CuSO_4, 5H_2O$, 97·5%; Fe, 0·065%; Zn, 0·15%.

As only a first-class grade of bluestone is being boxed for sale, the necessity of re-dissolving the low-grade bluestone cut the capacity of the plant down to such an extent that some other means of dealing with this product had to be devised. The present practice, which overcomes the production of any low-grade bluestone, is to by-pass, and run over scrap-iron, a definite quantity of mother liquor each week, returning the balance to the purified-liquor storage vat. By this means no building up of the zinc (which is the chief impurity) takes place, and a high grade of bluestone only is

made. The copper precipitates, produced from the mother liquor, which is by-passed, represent about 15% of the copper leached from the matte. It is roasted, and returned to the purifier as a source of CuO. The only bluestone now being re-dissolved is the undersize from the hutch of the washer. This is dissolved in mother liquor in an agitator provided with a paddle and steam coil. The crystals are added to the liquor until a specific gravity of 1·435 is obtained. The liquor is then run into the crystallizer with ordinary concentrated purified liquors.

The bluestone, as it comes from the crystallizing vats, has to be washed and freed from any very fine crystals. This is done in a jigger washer, having a fixed screen. Mother liquor is used as the wash liquor. The screen on the washer has 3/32 in. holes, which allow the undersized crystals to pass through into the hutch; from there they are periodically shovelled and sent to the re-dissolver. The washed crystals are shovelled off the jigger screen into a centrifugal drier, from which they are transferred, when properly dried, to a screen giving two sizes of crystals less and greater than ¼ in. The boxes used are made of pine, and have an inside dimension of 20 in. by 10 in. by 12 in. Each box is lined with brown paper before being filled, and holds 1 cwt. net of bluestone, of either the coarse or fine grade of crystals, and is branded C or F, according to which grade of crystals it contains. The assay-value of the finished article is as follows: Cu, 25·26%; $CuSO_4$, $5H_2O$, 99·23%; Ni, 0·002%; Zn, 0·09%; MgO, trace; CaO, trace; Al_2O_3 + Fe_2O_3, 0·07%; As, trace; Sb, trace; Se + Te, trace; Nitrates, nil; Insoluble, 0·02%.

It will be noticed that, although about 15% of the copper leached out of the high-grade matte is by-passed and precipitated on scrap-iron, the precipitated copper is roasted and returned to the purifier; therefore, by the method above described, a metal, which is looked upon as an impurity in lead smelting, is separated from the Au, Ag, and Pb, and converted into a profitable by-product.

Gyroscopic Surveying Compass. — In the MAGAZINE for April, 1920, reference was made to the gyroscopic compass, the principle of which lies in the fact that the axis of rotation of a rapidly rotating body tends to assume a position parallel to the axis of rotation of the earth. This type of compass is now being used in ocean-going steamers, and in the notice named we mentioned that the principle was being applied in Germany to mine surveying. Last month the specification of a patent, granted to Anschutz & Co., of Kiel, was published. This was numbered 18,346 of 1920 (146,372). We quote the specification herewith.

On the bed-plate 1, which is provided with foundation-bolts 2, is cast the horse-shoe-shaped bracket 3. The drawing shows only the rear branch of the said bracket; the front one is assumed to be cut off, the cut surface being visible at 4. On the inner sides of the branches of the said bracket 3 are mounted—shown dotted—supporting parts 5 on which a spherical vessel 7 rests, by means of flanges 6. This vessel is filled with mercury and contains a spherical float 8 which supports the gyroscopic compass 9 by means of a bracket 10 which is connected by a neck 11 to the float 8. Into a bore 12 of the neck 11 projects, through a bore 13 of the bracket 10, a centering-pin 14 secured at the top to the bracket 3.

In the gyroscope compass itself, the gyroscope casing 9 is supported by means of pins 15 in bearings 16 of the bracket 10, so that it may be turned about itself. On one side of the bracket 10 is mounted a spring-controlled locking-pin 17, which engages in the position illustrated, with a notch 18 provided in a plate 19, secured to the gyroscope casing 9. Exactly at an angle of 180° relatively to the notch 18 there is provided in the plate 19 a second notch 20, with which the pin 17 can also engage. The gyroscope casing may therefore be brought either into the position shown in the drawing, or into a position at angle 180° to the same. On the other side of the gyroscope casing, outside the corresponding bearing 16, is secured a cup 21, which is open at the side. Through the said opening is visible a mirror 22, secured by means of three screws 23, only one of which is shown in the drawing, to a part 24 on the bottom of the cup 21. This mirror is pressed outwardly by a spring 25 mounted in a bore of the part 24. By suitably setting the screws 23, the mirror may be brought into a position exactly at right angles to the axis $x—x$ of the gyroscope casing 9, or of the gyroscope body proper. The gyroscope body is not shown in the drawing. It is mounted in the usual manner within the gyroscope casing 9, on ball-bearings, which are provided in the pins 15. The cup 21, containing the part 24, is used for admitting lubricant, and the cup 26, which is provided on the plate 19, is intended for the same purpose. The cup 26 is further provided with a cock 27 through which air may be discharged from the gyroscope casing 9, or a light gas introduced into the casing for the purpose of reducing the surface friction of the gyroscope body. The instrument is closed by means of a sheet-metal cap 28, which is provided in front of the mirror 22 with an inspection opening 29.

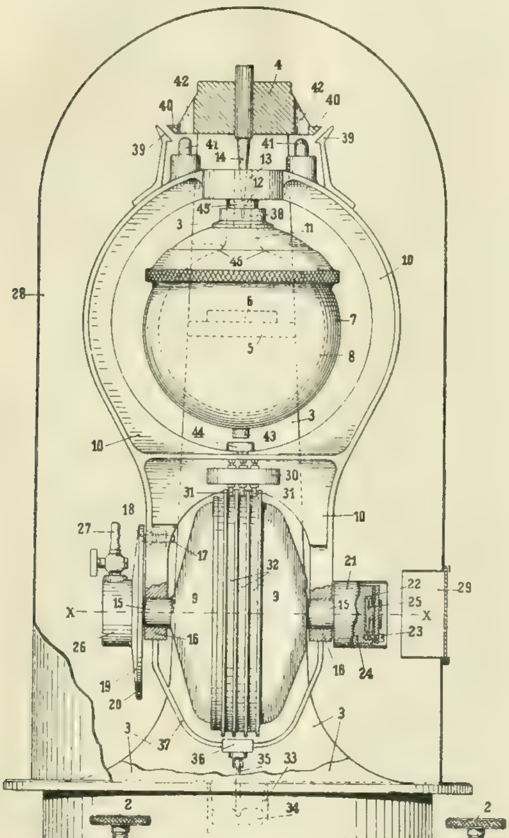
The gyroscope with the casing 9, bracket 10, and float 8, forms a floating system which can freely turn about the vertical axis and the geographical meridian. When the instrument has been steadied by hand to such an extent that only small oscillations take place, a reading can be effected with the assistance of the mirror 22. Then, as already stated, the gyroscope casing can be turned with the mirror to 180°, and the reading repeated, owing to which any errors in the setting of the mirror at right angles to the axis of the gyroscope are eliminated. Without this turning it is almost impossible to test the proper setting of the mirror if it is desired to keep the errors within the limits of one minute of arc or less. The securing of the mirror to the gyroscope casing presents the advantage that any changes of shape of the supporting bracket 10 and of the float 8 do not affect the reading.

The turning of the gyroscope casing with the mirror is of great importance. In order to do this, without interrupting the supply of current to the electric motor (in the construction illustrated a three-phase motor) driving the gyroscope body, the current supply is arranged in the following manner

The bracket 10 is provided with a brush-holder 30 on which are mounted three spring-controlled current-supply brushes 31. These slide on contact-rings 32 on the gyroscope casing 9, from which the three phases are supplied to the stator of an electric

motor, which is mounted in the gyroscope casing. The three phases are, however, supplied to the three brushes from the outside, without the free rotation of the floating system about the vertical axis being interfered with in the following manner.

On the bed-plate 1 is a mercury cup 33 containing the mercury 34. Into the latter dips a pin 35, which, by means of an insulating part 36, is secured to a member 37 depending from the bearings 16. Another mercury cup 38 is provided in the bore 12 of the neck 11, and into this dips the lower end of the centering-pin 14. Each of these two mercury



THE ANSCHUTZ GYROSTATIC SURVEYING COMPASS.

cups supplies one phase of current to one of the brushes 31, while the third brush is bodily connected to the bracket 10, and receives its current supply through the mercury in the vessel 7.

In order to make the instrument readily portable, on the bracket 10 are provided two spring-controlled hooks 39, which, when the whole bracket 10 is raised together with the float and the vessel, engage with corresponding projections 40 on the bracket 3, 4. Pins 41 on the bracket 10 engage then with suitable bores 42 of the bracket 3, 4, and a pin 43 engages with a suitable bore 44, also on the bracket 10, while at the same time the bottom end of the centering-pin 14 is enclosed fast by a half-ring 45 in the bore 12 of the neck 11. In that way the floating system is completely secured to the bracket 3, 4, while at the same time the upper opening of the mercury vessel 7 is tightly closed by the shoulder 46 of the neck 11. The instrument is therefore portable.

It is further pointed out that in the working position, between the circumference of the bottom end of the centering-pin 14, and the bore on the neck ring 45, there should be a clearance, in order not to disturb the free rotation of the instrument. This, however, does not affect the result of the reading, owing to the possibility of repeating the reading by turning the gyroscope casing with the mirror to an angle of 180°.

Indian Mining Laws.—In the *Journal of Indian Industries and Labour* for May, Sir Thomas H. Holland writes on the principles governing the grant of mining concessions in India. We give herewith his summary of the rules for the grant of prospecting licences and mining leases and we refer to his exposition of the principles in an Editorial.

Any British subject is at liberty to search for minerals in unoccupied and unreserved land which is the property of Government; but, before obtaining a prospecting licence or a mining lease, which carries with it certain privileges, he must obtain a certificate of approval from the local Government within whose jurisdiction the land lies for which the licence is required. A certificate of approval, which will hold good till the end of the calendar year, can be obtained for 50 rupees, and, if the local Government approve, can be renewed for a fee of 10 rupees.

The applicant for a prospecting licence is required to furnish a description of the land, illustrated by a map or plan, or alternatively, to peg out his claim according to a prescribed system; and when two or more applicants apply for the same land, the prior right to a licence, other circumstances being satisfactory, shall be deemed to lie with the applicant who first files his application with the Collector of the District.

Before a licence is granted the applicant must deposit either 100 rupees per square mile or part of a square mile, or give security to a like amount. The licence must then be executed within three months.

A district register of licences granted is open to inspection by any holder of a valid certificate of approval on payment of a small fee.

A licence is granted in the first instance for not more than one year, but may be renewed for a further term not exceeding two years.

The licensee has to pay a fee not exceeding one rupee and not less than one anna per annum per acre of the land taken up, and is required to pay royalty at a rate not exceeding 15% of the value on all precious stones that may be obtained, and, for other minerals over and above specified, small quantities allowed free, at the rates referred to below for mining leases.

The licensee requires the previous sanction of the local Government to transfer his rights to any other person holding a certificate of approval.

Within six months after giving up his licence, a licensee may be required to restore or to make safe any land opened up during his prospecting operations.

Each licence carries with it the right to claim a mining lease in accordance with the rules, the lease comprising the whole or a part only of the area covered by the prospecting licence, so long as the total areas leased does not exceed 10 square miles within any one province.

Before obtaining a refund of his security, a licensee may be required to disclose confidentially to Government any information obtained as to the mineralogical or geological nature of the area licensed.

In the case of mining leases, the applicant is required to deposit as security the equivalent of not more than 500 rupees, but any sum already held in deposit in respect of the prospecting licence will be carried forward to the applicant's account.

The application for a mining lease must be accompanied by a map or plan showing the boundaries of the area applied for ; or alternatively, the ground may be marked out as in the case of prospecting licences.

In the case of two or more applicants affecting the same land, not already held under a prospecting licence, the rule of priority holds.

A register of mining leases is kept in the Collector's office for inspection by holders of certificates of approval or their representatives on payment of a suitable fee.

No mining lease shall be granted by the local Government so as to cause the total area held under mining leases by the lessee or by those joint in interest with him to exceed 10 square miles within the territories administered by the local Government ; but the Government of India has power to grant areas in excess of this amount.

Without the previous sanction of the Governor-General in Council, or unless provincial rules are prescribed for special conditions, such as river dredging concessions, the length of an area granted under a mining lease shall not be allowed to exceed four times its breadth.

The boundaries below the surface of all areas given out on mining leases are regarded as running vertically downwards.

The term for which a mining lease may be granted shall not exceed 30 years, but the lease may contain a clause permitting renewal for another 30 years on a dead rent and surface rent not exceeding twice the original rents, the royalty payable being that which on the day following the expiry of the original lease shall be the royalty rate then in force.

A lessee, with the previous sanction of the local Government, can transfer his rights to another person or company holding a valid certificate of approval.

Unless prevented by reasonable cause, a lessee is required to commence operations within one year from the date of the execution of his lease, and is thereafter required to carry on the operations effectually in a proper, skilful, and mining-like manner. If a lessee, without reasonable cause, ceases to work the mine for a period not exceeding two years in such a manner as to produce sufficient mineral to earn a royalty at least equal to the dead rent, he will be liable to forfeit his leasehold rights, or may be required instead to pay a higher dead rent not exceeding twice the original rent.

A lessee is required to keep correct accounts showing the quantity of all minerals obtained, the number of persons employed, as well as plans of the mine, for Government inspection. He is required to allow existing and future adjoining licensees or leaseholders of land to have reasonable facilities of access thereto ; and is also required to report the discovery of minerals other than those specified in his lease

At the determination of his lease, he is required to deliver up the premises in a proper and workman-like state to the satisfaction of the local Government.

Any lessee is at liberty to relinquish his lease at any time on giving not less than twelve calendar months' notice and on payment of all sums that may be due, and cannot take a new lease for a portion of the land so relinquished.

The royalty rates prescribed by the rules include 5% on the sale value of ordinary coal, with a minimum of 2 annas per ton, and half these rates for coal dust. In the case of mica, the royalty is 5% on the sale value at the pit's mouth. For oil, the royalty is 8 annas per 40 gallons, or 5% *ad valorem* on the gross value ; and for gold and silver the rate paid is 7½% on the profits of each year taken separately, or 2½% on the gross value of the metal. Iron ore has hitherto been charged at the rate of half an anna per ton. Lease-holders for precious stones pay 30% on the net profits of each year taken separately ; and for all other minerals, not specified above, the rate is 2½% on the sale value at the pit's mouth, convertible at the option of the local Government to an equivalent charge per ton to be fixed annually or for a term.

Lease-holders are required to pay a minimum dead rent, which becomes absorbed by royalty. The minimum rates charged are four annas per acre for coal, lignite, and minerals used in agriculture and chemical manufactures, such as bauxite, gypsum, iron pyrites, and pyritous shales. For gold, silver, and precious stones, the minimum rate per acre is one rupee, and for iron ore one anna per acre. These minimum rates are liable to be exceeded according to the value of the deposit and the degree of the development of the area.

The annual surface rent charged for land actually occupied under lease is that assessable under the revenue and rent law of the province, or, if no such rent is so assessable, the rate may be fixed by Government, subject to a maximum on one rupee and a minimum of four annas per acre.

Origin of the Cost-book System.—At a recent meeting of the Royal Cornwall Polytechnic Society, Professor Henry Louis read a paper under this title, in which he gave an account of Roman tablets discovered in Portugal, these tablets containing inscriptions indicating the existence of a cost-book plan.

A few years ago it would have been hazardous to suggest that the cost-book system was a part of Rome's legacy to Cornwall, but an interesting discovery made in Portugal places this point beyond doubt. At the well-known argentiferous copper mines of Aljustrel, in Portugal, a bronze tablet had been discovered in 1876 beneath a heap of old slag, which gave some interesting particulars of the economic regulations that applied to these mines in Roman times. More recently, in 1906, a second tablet was discovered, the inscription on which shows the laws under which mining was carried on in this colony, and presumably also in others, and here it is interesting to note that we find the first traces of a well-developed cost-book system. The inscription dates from the reign of Hadrian. The relevant portions of the inscription may be translated thus :—

(2) Silver-bearing shafts shall be worked in the manner contained in this law ; the prices thereof shall be maintained according to the generosity of the most sacred emperor Hadrian Augustus, in such manner that the ownership of that share that shall belong to the Treasury shall belong to him

who first offers the price for the shaft and pays into the Treasury the sum of four thousand seterces.

(3) Whoever, out of five shafts, shall have sunk one down to the ore, shall work without intermission in the others, as is written above; unless he shall do so, others shall have power to occupy the same.

(4) If anyone, after twenty-five days given to preparation for the expenses, shall have forthwith commenced to carry out some work, but shall afterwards have ceased from working for ten successive days, others shall have the right of occupation.

(5) A shaft having been sold by the Treasury and having lain idle for six consecutive months, others shall have the right of occupying the same, provided that when ores are drawn from it one-half part shall, as is customary, be reserved to the Treasury.

(6) The occupier of the shaft shall be allowed to have such partners as he may desire, provided that the latter shall contribute to the expenses for that share by which he is a partner. Should he not do so, then he who has made the disbursements shall for three successive days in the most frequented part of the forum cause the account of the disbursements made by him to be published, and he shall intimate to the partners by the crier that each shall contribute to the expenses according to his share. Whoever shall not contribute, or with evil intent shall have done something so that he may not contribute, or shall deceive one or more of the partners, he shall be deprived of his share in the shaft, and the share of that partner shall belong to the other partners as they shall have paid the disbursements.

(7) And those colonists who shall have made disbursements in that shaft in which there shall have been several partners, shall be entitled to recover from their partners what shall be shown to have been expended in good faith.

(8) The colonists shall be allowed to sell among each other also such shares of the shafts as they may have bought from the Treasury and paid the price thereof, for as much as each one can obtain. Whoever wishes to sell his share or to buy one must make a declaration before the Warden in charge of the mines; it shall not be lawful to buy or sell in other wise. And whoever is in debt to the Treasury shall not be allowed to give away his share.

It will be seen that sections (6) and (7) really contain the essential regulations of the cost-book system; from the legal point of view nothing more is required, as we find here the power of making calls upon all the adventurers in a mine for expenses legitimately incurred and of forfeiting the shares of such of the adventurers as do not pay their calls. It is worth noting that such mining partnerships are to be met with wherever the influence of the Roman Empire can be traced, and that in a few cases they have survived up to the present time. The mining statutes of Trent, Iglesias, etc., all refer to it, and in Germany we have its survival, though in modified form, in the "Gewerkschaft," which was at one time almost identical with the cost-book company; we can even trace the introduction of the German terms, for in one of the Trent ordinances, dated 1214, we find the phrase "quattuor werki, silicet socii affidati." Again, the mining partnerships of the same type, as indicated in the Aljustrel Mining Law, are not known to modern Spanish Mining Law, but we find them set out with much detail in the mining laws of Spanish South America, which were derived from the Ordinances of Phillip II of 1584, which devote a section to mining partnerships, and enact regulations quite similar to the Roman ones though with more detail. A chapter of the modern Chilian Mining Law (Codigo de Mineria, 1888, Titulo XI, "De las Compañias Mineras") practically identical with that of the Argentine Republic of 1886, also includes a set of similar regulations.

There is thus excellent evidence that the principles of the cost-book system have come down to us direct from Roman times, and that it was the keen minds of Roman legislators that first devised this form of partnership, so admirably adapted to fostering mining enterprise.

The South-East Rand.—At a meeting of the Geological Society of South Africa held at the end of May, Dr. A. W. Rogers, Director of the Geological Survey of the Union of South Africa, read a paper entitled: "The Geology of the Neighbourhood of Heidelberg." Copies of papers read before the society are not available for general use until many months after they are read, so we take the following abstract of the paper from the *South African Mining and Engineering Journal* for June 4.

This paper describes the country between the Zuikerbosch Rand and the neighbourhood of Balfour. A coloured map accompanied the paper, on which the distribution of the rocks and the structure of the area were shown, and sections across the area were also exhibited. The most important result obtained in the demonstration was that each major subdivision of the Witwatersrand system diminishes in thickness southwards from the Rand, and that, in the country of which a geological survey has been made between the Klipriversberg and the Malan's Kraal–Tweefontein escarpment, there is no unconformity at the base of the Ventersdorp formation. The figures obtained for each major subdivision in Heidelberg are compared with the estimates made by Dr. Mellor on the Central Rand, and are as follows:—

	Central Rand.	*Heidelberg.*
	Feet.	*Feet.*
Kimberley-Elsburg series	6,120	3,560
Kimberley slates.......	500	370
Main-Bird series.......	3,160	1,020
Jeppestown series	3,700	3,000
Government Reef series	6,220	4,090
Hospital Hill series	4,900	3,180
	24,600	14,220

The Witwatersrand beds in Heidelberg are shown to be affected by many faults, and the relations between the faults and the many intrusions of igneous rocks are discussed in some detail. The most conspicuous dislocation, called the Sugarbush Fault, is later than most, if not all, of the minor faults, and later than most of the intrusions; it is an east and west fault which cuts off the Witwatersrand beds near Heidelberg from those near Balfour, and its throw diminishes westwards from at least 14,000 ft. near Eden Kop to some 3,000 ft. on Goedeverwachting, where it passes under the Karroo beds, which also conceal it beyond Eden Kop in the east.

The distribution of the conglomerates on each horizon on which they have been observed is described in the paper. Some of them are more persistent than others, and in general they are thinner and consist of smaller pebbles then the

conglomerates in similar stratigraphical positions on the Rand.

Certain strata in the Hospital Hill series, the Government Reef series, the Jeppestown series, and the Main-Bird series which possess characters rendering them valuable aids in addition to those already known for the purpose of correlating beds in more distant areas with the succession in Heidelberg, and through that with the strata on the Central Rand, are described in detail.

The paper also contained a discussion of the belief, prevalent in some quarters, that in Heidelberg the representative of the Van Ryn reef is to be found among beds which are regarded by the Geological Survey as lying above the Kimberley slates. It is shown that this belief is based upon incorrect data; that the maps published in support of it are inaccurate through errors in the position of outcrops of the Nigel horizon ranging from 500 yards to 6 miles having crept in; through the existence of important faults and large intrusions of igneous rocks having been overlooked; through the information to be got from the systematic and accurate record of position and dip of outcrops having been dispensed with; through the Bird amygdaloid on Maraisdrift and to the south of that farm having been mistaken for the Nigel slates; and perhaps through boulders of banket in the coal measure conglomerate having been mistaken for outcrops of banket in place. It is also shown that certain observations on cores from bore-holes, held by supporters of the erroneous correlation of Kimberley reefs in Heidelberg with the Van Ryn to prove that the Bird amygdaloid is an intrusive rock are wrong, and that the amygdaloid is a contemporaneous lava flow. It is also pointed out that the following assumptions made by the supporters of the erroneous correlation are mistakes: (1) a great unconformity at the base of the Ventersdorp formation, on account of which that formation in Heidelberg rests upon strata several thousand feet lower in the succession than it does in the Klipriversberg; (2) the persistence of character in individual beds of conglomerate on their several horizons wherever they are developed; (3) the existence of a fault between the Cason and Blue Sky shafts on the eastern side of which the beds are displaced towards the south, so that a reef with slate foot-wall in the east is brought into apparent continuity with a reef with quartzite foot-wall on the west. It is pointed out that the change in the nature of the foot-wall can be followed in detail, and that the reef is one and the same bed throughout.

Liquid-air Explosives.—The report of the Government Inspectors of Explosives for 1920 contains a brief reference to tests of liquid-air explosives. As is usual with Government reports the information published is meagre and non-committal, but we reproduce it herewith for what it is worth.

On October 8, 1920, experiments were carried out in Harefield Park, Middlesex, with liquid-air explosives, and were witnessed by two of the Government Inspectors. Representatives of the Admiralty, Board of Agriculture, and of county bodies were also present. The experiments were conducted by the Liquid Air and Rescue Syndicate, Ltd. The cartridges consisted of paper bags containing a carbonaceous absorbent material. A commercial No. 6 detonator was inserted and tied to the cartridge, which was then dipped into a container of liquid air. The liquid air had a high over 80% oxygen content. After being allowed to soak for about 15 minutes the cartridge was ready for use. The liquid-air container containing the cartridge was carried to the shot-hole, and as much as ten minutes were allowed to elapse between the time when the cartridge was taken out of the container and the firing of the shot. The cartridges with which the experiments were made were about 2⅜ in. in diameter and weighed about 2 lb. Single holes were bored under tree stumps about 18 in. in diameter without any other disturbance of the earth, and one 2 lb. cartridge was loaded and stemmed in each hole in the usual way. The shots were fired by electricity, and the results appeared to be satisfactory.

Sierra Leone Geology.—At the meeting of the Geological Society of London held on June 22, Frank Dixey read a paper entitled "The Norite of Sierra Leone."

The norite of Sierra Leone constitutes a complex of which the oldest and most important member is an olivine-norite. The complex forms the mountainous mass which, together with a narrow coastal plane of Pleistocene sediments, makes up the Sierra Leone peninsula. The norite was intruded in the form of a huge stock; it is thus very different from other well-known norites, which occur chiefly as laccolites or as special phases of larger masses of different composition. It does not appear to possess any marginal or basic modifications, while its junction with older rocks is obscured by the Pleistocene sediments. The complex is probably somewhat later than Pre-Cambrian in age, but in many respects it closely resembles certain well-known Pre-Cambrian masses. The main intrusion of norite was invaded in succession by the following related minor intrusions: (1) younger norites, (2) norite-pegmatite, (3) beerbachite, (4) norite-aplite, and (5) dolerite.

Important features of interest noted in the older norite are: (*a*) Well-developed flow-banding. (*b*) A series of binary and ternary intergrowths of the common minerals, indicating the importance of eutectic conditions during the crystallization of the magma. (*c*) Metamorphism due to the minor intrusions, which varies in intensity and character according to the nature and size of the minor intrusions. For instance, the younger norites and the beerbachite, not differing greatly from the older norite in composition, have caused extensive corrosion and even assimilation, but have not set up new minerals. The aplite and the dolerite, on the other hand, being relatively acid in composition, have, among other effects, converted the pyroxenes to amphiboles and modified the felspars. An interesting effect frequently observed in all phases of metamorphism of the norite is the recrystallization of part of the felspar and augite into graphic intergrowths.

The younger norites form two or more series of intrusions cutting the older norite, but they are collectively of small bulk as compared with the original intrusion. The field-relations of the older and younger norites are often very complicated, both on account of the irregular way in which the younger rocks have broken through the older, and of the extraordinary amount of corrosion and assimilation suffered by the older norite. The beerbachite intrusions are generally small and of irregular form; the larger intrusions actively disintegrated and incorporated the preceding intrusions of norite. The veins of norite-aplite generally occur

in the norite in the form of fine threads consisting mainly of quartz and micropegmatite. These threads, are, however, only the relatively-acid terminations of wider veins which are sometimes seen to attain a thickness of as much as 9 inches. The thicker portions of the veins consist chiefly of acid soda-lime felspar, orthoclase, quartz, and micropegmatite, with small quantities of pyroxene, hornblende, biotite, and apatite. The norite-aplite veins were succeeded by a series of more or less ophitic enstatite-dolerite dykes, free from olivine and rich in interstitial acid felspars. In many respects these dykes closely resemble the well-known British dolerites; they are, nevertheless, free from quartz and micropegmatite.

Iron ores occur in the norite as small masses up to several inches in length, as narrow schlieren, and as disseminated grains; they are highly titaniferous. Sulphides and other economic minerals often associated with noritic intrusions are rare or absent. The weathering and lateritization of the norite present some interesting features.

In the discussion following the reading of the paper, A. E. Kitson agreed with the view that the norite-mass had probably been intruded along a zone of faulting, and thus had determined to some extent the character of the coast-line of this part of West Africa. Since the norite-mass had not been foliated, he believed that it was later than Pre-Cambrian in age. The remnants of old platforms showed strong evidence of at least four successive uplifts, aggregating more than 1,000 ft. above sea-level. He agreed with the author that there had been a good deal of assimilation of the older norite by the younger intrusions. Examples of assimilation, though of different rocks, occurred in the Gold Coast. Although in the area between Freetown and the Hill Station there was a considerable amount of bauxitic laterite, he had not seen any blocks of bauxite.

The author, in reply, stated that iron ores occurred in the younger norites much as in the older norites, except that in the former they were present only as grains and small segregations, and not as schlieren. Also, bauxite occurred in small amount on outcrops of both the older and the younger norites.

SHORT NOTICES

Churn-drilling.—In the *Engineering and Mining Journal* for June 25, E. R. Rice commences an article on the churn-drilling of disseminated copper deposits.

Concrete Headgears.—The *Colliery Guardian* for July 1 and 8 contains a reprint of a paper read before the Liège Engineers' Association by C. Tournay on reinforced concrete headgears in France and Belgium.

Gold-dredge in Nevada.—In the *Engineering and Mining Journal* for July 16, G. J. Young describes the building of a gold-dredge at Dayton, Nevada.

Air-compressors. — The *Engineer* for July 22 publishes a report by Captain H. Riall Sankey on the Reavell quadruplex air-compressor.

Submersible Motors.—At the meeting of the North Staffordshire Institute of Mining Engineers, held on July 25, A. J. Ramsay read a paper on the application of submersible motors to mining work.

Galvanized Iron in Australia.—The *Industrial Australian and Mining Standard* for May 26 contains a description of the new works erected by John Lysaght (Australia), Ltd., at Port Waratah, Newcastle, New South Wales, for making galvanized-iron sheets. This company works in connexion with the Broken Hill Proprietary Co., and the technical skill is supplied by John Lysaght, Ltd., of Bristol.

Tungsten Filaments.—At the meeting of the Faraday Society held last month, C. J. Smithells read a paper on high-temperature phenomena of tungsten filaments, giving a record of some of his observations in the laboratories of the General Electric Company.

Estimation of Bismuth.—In the *Engineering and Mining Journal* for July 9, O. A. Critchett gives a new method of estimating bismuth in ores.

Lead Arsenate.—In the *Journal of Industrial and Engineering Chemistry* for June, O. W. Brown, C. R. Voris, and C. O. Henke describe a method of making lead arsenate by roasting a mixture of lead oxide and arsenious oxide.

Tellurium Alloys.—In *Chemical and Metallurgical Engineering* for July 20, J. H. Ransom and C. O. Thieme write on the effect of small quantities of tellurium in hardening and increasing the tensile strength of tin, lead, and white metal. It is believed that the action of the tellurium is to counteract the effect of other impurities rather than to form specific alloys.

Magmatic Differentiation.—In the *Journal of Geology* for June, J. H. L. Vogt commences an article on the physical chemistry of the crystallization and magmatic differentiation of igneous rocks.

Igneous Diffusion.—In the *Journal of Geology* for June, N. L. Bowen discusses diffusion in silicate melts.

Salt in Louisiana.—In the *Engineering and Mining Journal* for July 2, A. G. Wolf describes salt-mining operations in Louisiana.

Spitsbergen.—In the *Geological Magazine* for July Professor J. W. Gregory writes on the geological sequence across Central Spitsbergen from Advent Bay to Agardhs Bay.

Malayan Mining.—In the *Camborne School of Mines Magazine* for June, W. H. Eplett writes on lode mining in Malaya, giving particulars of work at Pahang, Bundi, Sungei Ayam, Intan, Sungei Gau, Menglimbu, Chendai, and Titi.

Peruvian Oilfields.—In the *Camborne School of Mines Magazine* for June, S. Raymond Prisk gives his "Impressions of an Oilfield", dealing particularly with conditions in Northern Peru.

Florida Phosphates.—In the *Engineering and Mining Journal* for July 16, S. L. Lloyd describes the method used in mining phosphates in Florida.

Gold Deposits in Peru.—The *Bulletin* of the Institution of Mining and Metallurgy for July contains a paper by A. Gordon Plews describing lode-gold deposits in the province of Pataz, Peru.

India's Hydro-electric Resources. — In the *Journal of Indian Industries and Labour* for May, J. W. Meares, electrical adviser to the Government of India, writes on the Government's policy with regard to the development of Indian hydro-electric power resources.

Colloidal Fuel.—*Engineering* for July 15 contains an article describing the use of colloidal fuel (that is, oil and pulverized coal mixed) at the works of the Steel Company of Canada, Toronto, for heating iron bars.

Carbocoal.—*Engineering* for July 29 gives further information relating to the Smith continuous carbonization process

RECENT PATENTS PUBLISHED

[illegible]

2,242 of 1920 (163,750). C. M. CONDER and G. T. VIVIAN, Camborne. Improved method of mounting jaws of rock breakers.

2,243 of 1920 (163,751). C. M. CONDER and G. T. VIVIAN, Camborne. Improved method of mounting crushing rolls.

4,988 of 1920 (165,144). F. B. JONES, E. BURY, and MINERALS SEPARATION, LTD., London. Improvements method of application of flotation to the recovery of fine coal, particularly from the dust evolved in the production of coal-gas, and the concomitant recovery of organic carbon compounds that go over with the coal.

6,268 of 1920 (164,444). R. and J. STRANG, Blantyre. Scotland. Means for stopping mine cages in case the rope breaks.

7,190 of 1920 (154,870). MINERALS SEPARATION, LTD., London. For floating oxidized ores of copper or lead, the use of 3 lb. of oleic acid and 2 lb. of silicate of soda.

7,260 of 1920 (140,096). L. P. BASSET, Paris. For reducing oxides, mixing with finely divided coal, and submitting to highly heated air, thus producing a reducing atmosphere of carbonic oxide.

7,839 of 1920 (164,852). H. F. H. SHIELDS and BRITISH ROPEWAY ENGINEERING CO., LTD., London. Improvements in boxheads or carriers used in the single-rope system of aerial ropeways.

8,247 of 1920 (163,856). A. M. READ, Columbus, U.S.A. A ball-mill with a number of separating grids, the spaces between each being provided with graduated balls.

8,573 of 1920 (164,547). R. MARTIN and J. I. RICHARDS, Swansea. Method of operating rakes in straight line roasting furnaces.

8,591 of 1920 (165,208). J. G. CLOKE, Tavistock. Concentration plant of the nature of the fixed buddle, consisting of a number of V-shaped launders.

8,960 of 1920 (140,824). UNITED LEAD CO., New York. Method of making hard alloys of lead containing small amounts of barium and calcium.

11,115 of 1920 (164,581). LINDSAY LIGHT CO., Chicago. Method of producing pure thorium compounds from monazite.

11,927 of 1920 (142,493). G. GRONDAL, Djursholm, Sweden. Apparatus for leaching copper ore that has been subjected to chloridizing roast.

11,981 of 1920 (149,316). TITAN COMPANY, Fredrikstad, Norway. Improved method of production of titanic acid pigment from ilmenite, the object being to get a whiter and smoother material.

13,652 of 1920 (165,298). SANDYCROFT, LTD., and W. BULLOCK, London. Improved method of operating the jaws of rock-breakers.

13,849 of 1920 (164,608). G. J. KROLL, Luxemburg. Method of making alloys containing alkali earth metals.

25,076 of 1920 (164,270). M. WHITWORTH, Oswestry. Forming the floor of sluice-boxes of perforated metal with the holes pointing slightly upstream, and sending a pulsating current of water upward through these holes.

28,886 of 1920 (163,957). S. HUNTER, Manchester. Improved construction of coal-washing jigs.

NEW BOOKS, PAMPHLETS, Etc.

Copies of the books, etc., mentioned below can be obtained through the Technical Bookshop of *The Mining Magazine*, 724 Salisbury House, London Wall, E.C. 2.

Elements of Engineering Geology. By H. RIES and THOMAS L. WATSON. Cloth, octavo, 370 pages, illustrated. Price 22s. net. New York: John Wiley & Sons; London: Chapman & Hall, Ltd. This book is in the nature of a condensation of the author's well-known book, *Engineering Geology*, reviewed in these pages in September, 1914; or perhaps a better idea of its scope would be obtained if we said it was intended as a textbook for a shorter college course on the subject.

Claims against Mexico. By R. F. DESVERNINE. Cloth, octavo, 150 pages. Privately printed. This books consists of a brief study of the international law applicable to claims of citizens of the United States and other countries for losses sustained in Mexico during the revolutions of the last decade. The author is a member of the New York Bar.

History and Present Conditions of the Oil Industry in Galicia. By Dr. S. JANICKI. Pamphlet, 40 pages. Price 2s. 6d. net. London: The Polish Press Bureau, 2, Upper Montague Street, W.C. 1.

Canadian Geological Survey's Summary Report, 1920, Part B.—Pamphlet, 72 pages, with numerous maps. This report contains the following articles: the Mesozoic of the Upper Peace River, B.C.; Review of Prospecting for Oil on the Great Plains; The Great Slave Lake Area; Oil-bearing Rocks of the Lower Mackenzie River Valley.

Bulletins of Indian Industries and Labour. By Dr. J. COGGIN BROWN. Published by order of the Government of India. No. 2. Manganese Ores; No. 6, Antimony, Arsenic, and Bismuth; No. 7, Wolfram; No. 9, Chromite and Molybdenum; No. 11, Tin. These bulletins give brief outlines of the occurrence of the minerals, of their commercial uses, of the methods of identifying them, and of the customs in the metal and mineral trades.

COMPANY REPORTS

Transvaal Gold Mining Estates.—This company was formed by the late Nicol Brown in 1882 to acquire a group of gold-mining properties at Pilgrim's Rest, in the Lydenburg district of the Transvaal. In 1895 it was amalgamated with the Lydenburg Mining Estates, since when it has been in the control of the Central Mining group. The report for 1920 shows that 155,063 tons of ore was mined and treated at the Central mines, 17,790 tons at the Elandsdrift mine, and 21,414 tons at the Vaalhoek mine. The revenues, gross and per ton, including premium, were respectively £251,420 or 32s. 5d., £64,336 or 72s. 5d., and £45,021 or 41s. 7d.; and the total revenue was £360,778, equal to an average of 37s. 1s. per ton The profit was £89,751 or 9s. 2d. per ton. Of the total revenue, £89,358 accrued from premium, a figure almost identical with the net profit. The shareholders received £15,105, the dividend being at the rate of 2½%. Development has been restricted by the shortage of native labour. Another feature in connexion with development is that at the Central mines the assay-value of the ore continues to show a slight decline. The reserves are estimated as follows: Central mines 461,958 tons, averaging 7·58 dwt. per ton; Elandsdrift 73,650 tons, averaging 16·2 dwt.; Vaalhoek, 67,262 tons, averaging 8·64 dwt.

Rhodesia Broken Hill.—This company works the lead-zinc deposits at Broken Hill, Rhodesia, which were described in detail in the MAGAZINE for October, 1919. Edmund Davis is chairman and Hooper, Speak & Co. are the consulting engineers. During the year 1920 the amount of ore smelted was 42,806 tons, and the yield of lead 14,602 tons. The whole of this ore was obtained from the open-cut at No. 1 kopje. In course of mining, 46,423 tons of ore high in zinc was extracted also, and this has been dumped for future treatment. The study of the zincy ore has been continued, and an experimental electrolytic plant capable of producing 50 lb. of zinc per day is in operation. The prospecting and drilling work and the geological investigations have been continued, and useful information has been obtained with regard to the mode of occurrence of the ore-bodies. The cementation process has been successfully applied to the sinking of the shafts through the heavily watered dolomite. At the end of the year No.1 shaft was down to 151 ft. and No. 2 to 50 ft. The sales of lead during the year brought an income of £461,677, and £4,431 was received for vanadium ore. The net profit was £89,949, out of which £35,000 has been declared as dividend, being at the rate of 10%, less income tax. The output of lead during the first half of 1921 was 9,428 tons.

Eileen Alannah.—This company belongs to the Willoughby group and has worked gold mines in the Gatooma district, Rhodesia, since 1911. The ore is refractory, and there have been breaks in the continuity of operations. The report for 1920 shows that 21,720 tons was milled, yielding 4,788 oz. by amalgamating, grinding in pans, cyaniding of concentrate, and cyaniding of sand. The bullion realized £25,795. In addition a tributer extracted gold from accumulated slime, the royalty on which accruing to the company amounted to £130. The accounts show a loss of £1,950, bringing the total debit balance to £25,816. In February, 1921, there was an exceptionally heavy rainfall, as much as 9 in. being registered in a week. In consequence the workings were flooded to near the surface. The pumps have so far made little impression on the water, and it is possible that the property may be abandoned, for the present at any rate. Perhaps the oxidized ore in the open-cuts may be worked, if not the sulphides below.

South Kalgurli Consolidated.—This company was formed in 1913 to amalgamate the South Kalgurli and Hainault gold mines at Kalgoorlie, West Australia. The report for 1920 shows that 80,270 tons was milled for a yield of 30,915 oz., equal to 7·7 dwt. per ton. The par value of the gold was £130,992, and £51,284 was received as premium. The net profit was £36,344, out of which £31,250 is being paid as dividend, being at the rate of 25%. The ore reserve is estimated at 179,900 tons, together with a probable 88,100 tons. Development is still being actively continued, though no new discovery of note has been made since that of June, 1919, which, as John Morgan, the consulting engineer, says, was so effective in raising the general grade of the ore treated.

Associated Gold Mines of Western Australia.—This company was formed in 1894 to work the Australia leases at Kalgoorlie. Of recent years the ore has been of low grade and no dividends have been paid since 1914. The report for 1920 shows that 64,462 tons of ore was treated for a yield of gold realizing £121,614, of which £35,439 accrued from premium. In addition £5,174 was received as royalties from tributers. After writing off the cost of development and diamond-drilling, a profit of £25,624 was made. From this is deducted £8,864, the adverse balance brought in from the previous year, leaving a credit balance of £16,760. D. F. McAulay, the manager, states that exploratory work has proved the continuance of the Australia East lode in depth. The company holds interests in the Keeley Silver Mines and the Porcupine V.N.T. companies operating in Canada. The former started milling recently, but nothing is being done at the latter owing to the continuance of high costs.

Lake View & Star.—This company was formed in 1910 to amalgamate the Lake View Consols and the Hannan's Star companies, after the former had ceased to be a great producer. In 1915 the Chaffers mine was purchased. During the year 1920 the ore raised and treated amounted to 95,157 tons, and the yield of gold was 25,541 oz., the par value of which was £108,881. Gold premium and a small amount of royalty received from tributers brought the income to £168,489. The working profit was £27,494, of which £3,000 was written off for depreciation and £22,500 was paid as dividend, being at the rate of 11¼%. Developments during the year have not given any results at Lake View or Hannan's Star, but additional ore has been disclosed at Chaffers. The main shaft at Lake View has been sunk deeper in order to open a new level at 2,300 ft. The ore reserves are estimated as follows: Lake View, 58,589 tons, averaging 28s. 9d. per ton; Hannan's Star, 178,453 tons, averaging 25s. 8d. per ton; and Chaffers, 5,400 tons, averaging 40s. 4d. per ton; all par values.

Oroya Links.—This company was formed in 1896 as Golden Link Consolidated to acquire properties at Kalgoorlie. In 1909 the name was changed and milling plant was acquired from the Oroya Brownhill company. Operations were suspended in 1916, and part of the property has been let on tribute. J. H. Cordner-James is chairman, and Bewick, Moreing & Co. are the general managers. The report for 1920 shows that the tributers extracted 13,137 tons of ore, and that 5,765 tons of ore was purchased. The net profit was £2,537, which was carried forward.

British Broken Hill.—This company was formed in 1887 to acquire Blocks 15 and 16 at Broken Hill, New South Wales. The report now issued covers the year 1920. The mine and dressing plant were closed on account of the strike for 19 months. Mining was resumed on November 16, 1920, and from then until the end of the year 660 tons of carbonate ore was raised, averaging 28·5% lead and 5·3 oz. silver per ton; also 13,756 tons of sulphide ore, averaging 12·8% lead, 11·8% zinc, and 7·3 oz. silver. The lead concentrator treated 14,279 tons, and produced 2,330 tons of lead concentrate, averaging 60·7% lead, 7·3% zinc, and 26·4 oz. silver. At the zinc flotation plant 10,636 tons of lead-mill residue, averaging 12·6% zinc, 3% lead, and 3·1 oz. silver, was treated, yielding 2,120 tons of zinc concentrate, averaging 45% zinc, 9% lead, and 10·8 oz. silver. After the turn of the year the fire at Port Pirie smelting works and the general adverse conditions made it necessary to stop work at the end of January. The accounts for the year showed a loss of £47,757. The reserve of sulphide ore is estimated at 1,057,905 tons, averaging 12·4% lead, 11·3% zinc, and 6·9 oz. silver.

Briseis Tin & General Mining.—The company has worked alluvial tin deposits in north-eastern Tasmania since 1899. The report for 1920 shows that 181,981 cu. yd. of ground was treated at Briseis, [illegible] a yield of 219·8 tons of tin concentrate, the extraction per yard being 2·72 lb., while at Ringarooma 115,500 cu. yd. yielded 23·5 tons, being at the rate of 0.45 lb. per yard. The total production was 244 tons. This was smelted at the company's works at Launceston, and the metal obtained, 176¼ tons, sold for £46,155. The working profit was £15,467, out of which £2,229 was written off for depreciation, and £7,368 was allowed for British and Colonial taxes. Arrangements are being made for diverting the Ringarooma river once more to bring it behind the working faces by means of a high embankment. Until this work is completed the output of tin concentrate will be necessarily restricted.

Kramat Pulai.—This company belongs to the Tronoh group, and was formed in 1907 to work alluvial tin properties at Pulai, in the Kinta district of Perak, Federated Malay States. Subsequently deeper leads containing scheelite were worked, according to the demand for this mineral. A year ago it became necessary to provide rock breakers for disintegrating the scheelite-bearing material. The report for 1920 shows that the output of tin concentrate was 112 tons and of scheelite 194 tons. The production of scheelite was suspended in September owing to the low price obtainable. The accounts show receipts of £34,326 from the sale of the company's products and of £4,289 from tributers. The net profit was £15,194, and, with the amount brought in from the previous year, the credit balance on December 31 was £24,937. Dividends absorbing £20,000 have been paid, being at the rate of 20%.

Gurum River (Nigeria) Tin Mines.—This company was formed in 1911 to work alluvial tin property in the north-western part of the Bauchi plateau, Nigeria. Oliver Wethered is chairman, J. M. Iles is on the board, and Laws, Rumbold & Co. are the general managers in Nigeria. The report for the year ended September 30, 1920, just published, shows that the output of tin concentrate was 176 tons, as compared with 104 tons the previous year. The receipts from the sale of concentrate were £21,353, and the net profit was £2,923. Adding £14,010 brought forward from the previous year, the disposable balance was £16,934. Out of this £12,316 has been distributed as dividend, being at the rate of 15%.

Naraguta Extended (Nigeria) Tin Mines.—This company has worked alluvial tin ground in the northern part of the Bauchi plateau, Nigeria, since 1911. The report for 1920 shows that the output of tin concentrate was 224 tons, as compared with 276 tons the year before. The fall was due partly to labour shortage, but also to the supply of water during the rainy season not being up to the average. The accounts showed a credit balance of £359 for the year's working. At the present time the property has been let on contract.

Kaduna.—This company was formed in 1910 to acquire alluvial tin properties on the western side of the Bauchi plateau, Nigeria. J. E. Snelus is the manager. The report for the year ended October 31 last shows that the output of tin concentrate was 168 tons, as compared with 205 tons the year before, the fall being due to the shortage of efficient native labour. The accounts show credits of £21,361 from the sale of tin, and a loss for the year of £482. The sum of £3,699 was brought forward from the previous year, and £7,360 was recovered from excess profits tax previously paid. The balance in hand was therefore £10,576, out of which a dividend at the rate of 10% was paid, absorbing £2,780. Additional prospecting licences have been acquired during the year.

Kaduna Prospectors.—This company was formed in 1913 as a subsidiary of the Kaduna Syndicate, and now works alluvial tin property in the southern part of the Bauchi plateau, Nigeria. The report for the year ended October 31 last shows that 90¾ tons of concentrate was won, as compared with 58½ tons the year before. The accounts show a loss of £750. Additional ground is now being examined under prospecting licence.

Burma Ruby Mines.—This company has worked ruby mines at Mogok, Burma, since 1889. During 1920 the amount of earth washed was estimated at 771,406 truck-loads and the stones recovered were valued at £43,010. The sales brought an income of £33,507. There is a steady demand for the ordinary qualities of stones in India and Burma, and fine stones are always in demand in London and Paris. Large sections of ground are worked by tributers, and the royalties collected during the year amounted to £14,528, which, less cost of collection, was handed over to the Indian Government. The accounts for 1920 show an adverse balance of £5,929. During the year sluicing has been introduced, and water is now brought in instead of the earth being hauled to the washers. In this way the cost of operation will be greatly reduced.

Poderosa.—This company was formed in 1908 to acquire copper properties in the Collahuasi district, Chile. The ore is of high grade, but conditions of work are difficult; moreover, the marketing of the ore has been subject to frequent interruptions during recent years. Dividends were paid for 1909, 1916, and 1917. The report for 1920 shows that 5,011 tons of ore, averaging 30·13% copper and 15·16 oz. silver per ton, was shipped to the smelters, as compared with 1,498 tons of similar tenor the year before. The operations during the first three quarters of 1920 were fairly remunerative, but with the fall in the price of copper it became impossible to ship at a profit, so that since October work has been confined almost entirely to development. The accounts show receipts £108,620 from the sale of ore and a profit, after allowance for development and depreciation of plant, of £18,349, out of which £8,750 has been distributed as dividend, being at the rate of 2½% less income tax. R. O. Packard, the manager, gives particulars of current and projected development. He estimates the ore in the Poderosa mine ready for shaping at about 10,000 tons, averaging 25 to 30% copper, and the concentrating ore on the dumps at 134,000 tons, averaging 3½% copper.

Libiola Copper.—This company has worked a copper mine in the north of Italy since 1888. The report for 1920 shows that the yield of copper ore was 2,297 tons and of pyrites 6,309 tons. The demand for cupreous pyrites improved during the year. Owing to labour unrest, operations were on a comparatively low scale, and no development work was done. The reserve is estimated at 6,325 tons of copper ore and 37,560 tons of pyrites. The profit and loss account shows a credit balance of £234.

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EDITORIAL

THE Engineers' Club was formally opened on September 1. The Club occupies a handsome house at the corner of Coventry Street and Whitcomb Street, between Leicester Square and Piccadilly Circus. The honorary secretary is Mr. E. L. Hill.

ONLY last month we referred with commendation to Sir Thomas Holland's services in the administration of certain branches of Indian Government business. It is unpleasant, therefore, to have to record that he has had to resign his position as member for commerce on the Council of the Governor-General of India. He ordered the abandonment of a prosecution, which the legal members of the Government considered should be continued. Here, again, it is of little avail to plead that his actions were prompted by notions of public duty. We can only express regret that his undoubted abilities and his sympathetic methods of handling native questions should be lost to the Government at a time of anxious national stress.

ONE of Mr. E. H. Clifford's recommendations relative to winding from great depths, contained in his paper on the City Deep mine read before the Institution of Mining and Metallurgy early this year, was that cages and skips should be made of the strongest steel or other alloy obtainable, in order that their weight should be reduced to the lowest possible limit. It is obvious that the lightening of the hoisting load obtained thereby would effect an important economy and substantially reduce the working costs, in spite of the fact that the first cost would be considerable. We hear, however, that inquiries made by mining houses do not receive a ready response from the constructional engineers, who appear to be rather doubtful as to the advisability of such a policy. We can assure the manufacturers that the matter is one well worth their attention.

IN memory of Thomas Newcomen, the pioneer of steam engineering, a monument has been erected in his native town of Dartmouth, being placed in the public park facing the River Dart. The monument consists of a large, rough-hewn granite block, to which is affixed two brass tablets. One of the tablets gives in a few words an outline of Newcomen's career, and on the other there is an engraved representation of his invention, the atmospheric steam engine. Newcomen was born in Dartmouth in 1663, where he first earned his living as a blacksmith. The house he lived in was in existence until 1884. The records show that he built an engine near Dudley Castle in 1712, and the last that was at work was at the South Liberty coal mine near Bristol. He died in London in 1729, and he was buried in Bunhill Fields cemetery, which is situated about half-way between the old and the new homes of the Institution of Mining and Metallurgy.

AT the annual meeting of the Cornish Chamber of Mines, certain members forcibly expressed their disapproval of words in the editorial on Cornish Conditions appearing in the MAGAZINE last month. The offending words were : "Cornish mining is dead." Without their context and without further amplification the statement appears sufficiently alarming. But the word "dead" is one of elastic definition, as will be found by reference to the Oxford Dictionary. We did not mean it in the sense of Artemus Ward's "killed fatally dead," but rather in the mode of language of the stockbroker, who at present loudly avers that the rubber share market is "dead." "Inactive, motionless, idle," are given in the Oxford Dictionary, and this is the sense in which it was used by us. A more considered phrasing of the words and their context would be : "Cornish mining is temporarily dead, and there are no signs of an immediate revival." Mr. R. Arthur Thomas at the meeting put it concisely when he said : "Cornish mining is not dead, but sleepeth."

Carbonic Oxide Poisoning

On several occasions recently we have drawn attention to the dangers arising from the gradually extending use of carbonic oxide in metallurgical and other industrial and domestic operations. Owing to it being without colour and odour, its presence is not detectable until unpleasant physical symptoms arise, and for the same reason the symptoms are not easily recognizable as the result of this particular form of gas

poisoning. In mining operations its effect is not as generally understood as it should be, and the headache following exposure to the fumes of blasting is often wrongly attributed to nitrous compounds. Though various writers have given the results of their investigations into the composition and effects of the fumes given off by explosives, the action of carbonic oxide has not received the attention it deserves, owing presumably to the comparatively small proportion present. One of these days a medical man will devote himself to the study, in the same way as Dr. Leonard Hill has made a speciality of the effects of moisture in hot atmospheres. The remedy will probably lie in regulation of times of blasting, rather than in the matter of ventilating, but the subject will afford considerable scope for investigation. In coal-mining the gas is known as "white damp," but the effect of its presence after an explosion of coal gas or coal dust is often ignored, and it is only recently that the necessity for providing means for combating its effect during first-aid and rescue operations has been recognized.

The dangers arising in industrial operations from the use of commercial gases containing carbonic oxide, and from its incidental formation and escape, are fully understood by the Home Office, for a number of publications have been issued dealing with various phases of the subject. One of these was issued last month by the Factory Department, entitled "Memorandum on Carbonic Oxide Poisoning in Factories." This pamphlet contains a large amount of information of value to metallurgists and to users of gas engines and plant in which gas is employed for heating purposes. At so many mines and metallurgical works gas is used nowadays that this pamphlet ought to be in the hands of all our readers. It is not possible here to give anything like full quotations, but one point raised is deserving of special reference. The dangers are often entirely unsuspected, and in the specific case mentioned deaths have been known to occur owing to the slow smouldering of coal and other carbonaceous matter in dumps. The gases released by this action permeate the soil and gain access to buildings. In the same way gob fires in coal mines are dangerous, for this reason as well as on account of the heat evolved, though in these cases the ventilating current usually provides sufficient remedy.

In factories and mines it is possible, by observing certain rules, to keep clear of the dangers of carbonic oxide, and in well-organized establishments there are means for instantly combating its effects when the symptoms arise. Under these conditions there seems no reason for agitating against the use of gases containing this highly poisonous constituent. On the other hand, the increasing proportion of carbonic oxide in town gas used for household purposes is open to considerable objections, and the recent report of a Board of Trade committee refusing to recommend a limit must be viewed with some disquietude. The battle of twenty-five years ago between the water-gas fraternity and the anti-poison group will be remembered. The result at the time was a curbing of the general expansion of the use of this gas, but two factors in the problem have since arisen to change the point of view. In the first place the incandescent mantle requires heat and not illuminating power in the gas employed, while the gas-works desire an outlet for their coke. Thus the Gas Regulation Act, passed a year ago, allowed the gas companies to sell gas by heating power instead of illuminating power, and they were given a free hand with regard to carbonic oxide content, subject to the decision of a committee appointed by the Board of Trade. This committee met a great many times, and examined a number of expert witnesses. The opinions expressed differed fairly widely, but the general view appears to have been that as straight coal gas contains 9% of carbonic oxide, there can be no serious objection to higher proportions being used. While many experts pressed for a maximum of 20%, the preponderating view was that no limit should be imposed. It cannot be denied that the members of the committee and the experts are well informed men, but the average user of gas feels that their judgment is open to criticism, and that there is something wrong somewhere. The gas companies claim that they are benefactors to the race because their product gives no smoke and no fumes to destroy buildings; they must not object if they receive a retort to the effect that they introduce a virulent poison into our houses. There is reason to doubt the sincerity of the altruistic attitude assumed by the lighting and heating corporations, for are not the electric lighting stations the worst offenders in the matter of discharging black smoke into the

atmosphere. The cynic will go almost as far as to say that these clouds of smoke are good for the companies, as they create a demand for artificial light. Seriously, however, the carbonic-oxide position is unsatisfactory, and much has still to be learnt by producers, users, and experts. Watch will undoubtedly be kept on the results of the recent removal of restrictions, and the matter will be revived at a later date. As far as this MAGAZINE is concerned, it is impossible to do more now than to question the wisdom of allowing unlimited use of this gas.

The Metalliferous Mines Advisory Committee

As mentioned in the June issue, the Secretary for Mines recently appointed an Advisory Committee for the Metalliferous Mining Industry. No doubt many readers are sceptical of the value of any departmental committee, and judging by past experience they have good reason for such disbelief, for the permanent or political Government officials have usually ignored the recommendations of such advisers. But this attitude of scepticism is surely wrong, for everybody connected with metalliferous mining in this country should endeavour strenuously to back their interests and take full advantage of the opportunity now offered for doing some good to an industry which is confessedly in a parlous position. Anyway, most of the committee take a serious view of their duties, and they should be generously supported in mining circles. Among the members of the Committee best known to readers of the MAGAZINE are Dr. F. H. Hatch, Dr. Malcolm Maclaren, Professor Henry Louis, and Messrs. Frank Merricks, F. W. Harbord, R. Arthur Thomas, Anthony Wilson, and T. C. F. Hall. The committee consists essentially of representatives of owners of iron, tin, and other metalliferous mines, and of an equal number of representatives of labour, together with mining engineers, geologists, and metallurgists, and a medical expert. If there is a criticism to be made with regard to the constitution of the committee it arises from the appointments to the chairmanship and vice-chairmanship. Sir Cecil Budd is the chairman, and it is generally felt that this office would have been better held by some one conversant with mining rather than by a representative of the metal markets; while it is considered in some quarters that the presentation of the vice-chairmanship to the Labour party gave the Committee too much of a political complexion. These points are not of any great practical importance as matters go nowadays, and it is well to dismiss the criticisms as promptly as possible. The great point in connexion with the Committee is that its formation marks a new era in administration, and that for the first time in our history the owners and workers have a direct and legitimate voice in such control as is exercised by a Government department. The Committee has the widest functions, and though the Minister is not compelled to refer any question to it, undoubtedly he will have in practice to obtain the opinion of his advisers. It is also laid down in the constitution of the Committee that the Minister " shall take into consideration any representations which may be made to him by the Committee," a clause which gives a right that may prove to be of immense value to the industry. As regards recommendations involving the spending of money, the Committee was told at its first meeting that the limit of expenditure by the Mines Department had already been reached, so that no such recommendations could be considered. This, of course, excludes a great many matters that would otherwise have been brought forward, and has accordingly caused much disappointment to a large section of the non-ferrous mining community.

One of the recommendations already made by the Committee relates to the collection of statistics of production and labour. Of recent years the Home Office reports on these matters have grown more and more absurd, as regards both scantiness and dilatoriness of publication. The mine owners send full returns in January, and an ordinary business house would be able to publish the reports in February. But the reports are generally published towards the end of the year, when they are of little use to those engaged in the industry or to anyone else. The Committee is now urging a reform in this method of presentation of the returns, and is also urging their publication, especially those relating to labour, at shorter intervals, say quarterly.

The Minister of Mines has placed before the Committee the recommendations of the various Commissions that have examined the conditions of the mining industry of late years, in particular the Royal Commission on Metalliferous Mines and Quarries,

the Royal Commission on Royalties, and the Departmental Committee on the Non-Ferrous Mining Industry. Up to the present time no effort has been made to carry out these recommendations, and the various reports have been entirely neglected. They are now being considered by the Committee, and it is probable that many of the recommendations contained in them will be endorsed by the Committee, and probably accepted by the Minister. It will hardly be possible to deal with all these matters by immediate legislation, and in any case there is great difficulty in drafting an Act of Parliament in a sufficiently comprehensive manner to include all the regulations that would be necessary, so in all probability the most urgent matters will be dealt with by means of special rules and Mines Department regulations, which, when formally issued, have all the force of law. In preparing the rules, it is of importance that they should be adapted to each class of metalliferous mining, for it is clear that what is suitable for open-cut ironstone mining in the Midlands is not easily adaptable to tin-mining operations. Then, again, local nomenclature should be considered, for the terms used in the various districts differ widely. Even in Furness, the words and their meanings are not all identical with those employed in the neighbouring iron mines in Cumberland, while Cornwall has a dialect of its own. Sub-committees have already been formed to consider the qualifications of managers, the keeping of plans, the rules for safety and health, and other subjects.

Probably the question of royalties, way-leaves, and rates will receive close attention by the Committee. It is to be hoped that the new statistical returns will give the information, which has hitherto been unavailable, relating to the amounts paid by the mines under these headings. Curiously enough, the Royal Commission on Royalties was unable to secure exact data, a fact which went far to nullify any good done by the inquiry. The Government is pledged to the nationalization of royalties, and it is clear that full details must be obtained before any legislation can be undertaken. Both mine owners and the workers are aware of the heavy handicap of these charges, and are equally helpless in the matter. It is true that occasionally a royalty owner will alleviate the burden under special circumstances, but nothing but public regularization will really meet the case.

3—3

It will therefore be one of the duties of the Committee to advise as to the terms of nationalization. The incidence of local rates is not of less importance than the imposition of royalties, and it will also receive due attention.

The Committee has started well, and it will no doubt make its position felt. Outside support must be given to it so that it shall be able to avoid the fate of similar bodies, which have gradually sunk into the apathy consequent on neglect. It must not stop at mere advice on official proposals, but should boldly handle all the factors that have so largely contributed to the existing desperate position. We may hope that the Minister of Mines will make full use of the Committee, and treat its recommendations with sympathy and intelligence, and give it a status that will encourage it to throw itself with energy and responsibility into the task before it.

Shetland Copper

As recorded in recent issues, a project is in hand for the reopening of the old copper mines in the Mainland of the Shetland Isles. At the time we recommended inquirers to consult Dr. J. S. Flett, director of the Geological Survey, with regard to this subject. Since then a report by Dr. Flett has been issued by the Scottish section of the Geological Survey, giving a historical account of these ore deposits, so the public are now in possession of all essential details.

The deposits are found in the Old Red Sandstone of the Devonian Age. These rocks are principally conglomerates, red sandstones, and shales, with occasional thin-bedded grey flagstones. The area covered by the rocks extends from Rovey Head, a few miles north of Lerwick, the capital of the Isles, along the eastern side to Sumburgh Head, at the extreme south of the Mainland. To readers of Sir Walter Scott the country will be familiar as providing the principal scenes in " The Pirate." Pyrites and chalcopyrite are found in lodes in these Old Red Sandstone rocks, and at a number of places these lodes have been worked for copper at various times. The most important of the operations have been at Sandlodge, which is situated about 14 miles south of Lerwick. The lode trends about N. 10° E., and three old shafts are marked on the 6 in. ordnance survey map. The country rock is reddish sandstone, and the weathered back of the lode can be seen in some old pits. The

lode consists largely of siderite, which is weathered to limonite on the surface to a depth of about 100 ft. The pyrites is found in stringers and pockets, and other sulphides, such as galena and blende, are also present. The deposit was originally worked for copper ore, but at one time iron ore was also mined. In depth the siderite gives place partly to carbonates of lime and magnesia. The lode is fairly wide, measuring 9 or 10 ft., and there is also a subsidiary lode. The foregoing facts give a general idea of the nature of the deposit, but it is interesting also to record the history of the work done.

The early records indicate that the Sandlodge mine was first opened toward the end of the eighteenth century, and that a party of miners was brought over from Wales to do the development. Shafts were sunk, and copper ore was raised, selling for about £2,000. The death of the lessee put an end to the operations before much work was done, but by the year 1800 mining had been resumed. Robert Jamieson, in his *Mineralogy of the Scottish Islands*, describes his visit to the property in 1799. According to his account, two lodes had been worked, known as the east and west veins, and forming branches of one lode. In 1803 Patrick Neill was there, and he gave his impressions in his *Tour through some of the Islands of Orkney and Shetland*. He found that a shaft was down to 130 ft., and that one or two cargoes of dressed ore had been shipped. He was told that the company had spent £10,000 on the mine, and that the best quality of picked ore realized £70 per ton. John Sherriff, in his book *A General View of the Shetland Islands*, published in 1817, mentions that Professor Fleming visited the district in 1808. The mine had been abandoned by that date and the shafts were full of water. From time to time during succeeding years the property was worked on a small scale with unimportant results, and it was not until 1872 when John Walker obtained a lease that public attention was attracted once more. Mr. Walker carried on work actively for eight years, and raised about 10,000 tons of iron and copper ore. In 1878 the production of copper ore was 708 tons, valued at £1,770, and of iron ore 1,241 tons, while in 1880 the yield was 1,995 tons of copper ore valued at £5,814 and 396 tons of iron ore valued at £344. Mr. Walker sold the lease in 1880 to the Sumburgh Mining Company, which had a nominal capital of £60,000, but this company went into liquidation in the following year. Since then the property has been examined on many occasions, but reopening was never recommended, until in November last the present enterprise was inaugurated.

One of the most enlightening accounts of the deposit written in recent years is found in a paper read in 1908 by Mr. R. W. Dron before the Geological Society of Glasgow, entitled "Iron and Copper Mining in

Geology of South of Mainland of Shetland Isles.

Shetland." He gives some idea of the nature of the deposit and of the ores mined. He states that the lode averaged 9 or 10 ft. wide and that the west shaft had been sunk on the incline to a depth of 180 ft. For the first 100 ft. the lode appeared to have consisted of hematite and limonite, the weathered products of siderite, with here and there pockets of copper pyrites. He was informed that the iron oxides had been shipped to gas works for use as a desulphurizer. Below the 100 ft. level, he reported the lode material to be siderite, associated with carbonates of iron and

magnesia, and that this also contained copper pyrites. Also he mentioned that a vertical shaft had been sunk to cut the main lode at a depth of 240 ft., and that below this point the shaft had followed the lode for 60 ft., and levels driven northward and southward for 220 ft. and 190 ft. respectively. In these bottom workings the lode material is reported to be white siderite, containing copper pyrites, but Dr. Flett is of opinion that its composition is vary variable.

Dr. Flett in his report mentions a number of other spots where copper pyrites is known to exist in this district. At Setter, about half a mile south of Sandlodge, a lode has been known for many years, and an attempt was made to work it in 1890. Two shafts were sunk. One of these was near the coast line, and followed the lode for 90 ft. The vein was of solid copper pyrites, but it was narrow, being only a few inches wide at the surface and 15 to 20 in. at the deepest point worked. The proximity to the sea made it impossible to continue the sinking of the shaft, so a second shaft was started about 150 ft. inland, and on higher ground. This shaft was sunk to 83 ft., and a cross-cut was then started to intersect the vein, but at this stage the venture was abandoned. Copper pyrites is also found on the cliffs at Sandwick and No Ness, not far from Sandlodge, and the lode is presumably a continuation of that worked at Sandlodge. Other trials have been made at Levenwick, Hoswick, Garthness, and Quendale. Fair Isle, situated about half-way between Orkney and Shetland, belongs also to the Sumburgh estate, and here there is another outcrop of copper pyrites, which has been investigated at various times during the last hundred years, but neither its nature nor its position has been such as to encourage exploitation.

From the description of these deposits it would appear that they resemble more or less closely the siderite lodes north of Perranporth, Cornwall, to which attention was drawn in these pages about four years ago. They do not seem to afford much hope for success. Dr. Flett says it is quite possible that with modern methods of mining and dressing there may still be a future for the Sandlodge mine, but this is evidently more of the nature of a polite reservation than an actual opinion. For ourselves we do not consider that the project of reopening this mine is a suitable subject for paragraphs in the financial dailies.

Reference is made in the foregoing article to Sir Walter Scott's romance "The Pirate," in which many of the scenes are placed in Shetland. In the course of the story, he makes mention of the copper deposits, and as the account given is appropriate to the present position, we give extracts herewith.

One of the characters in the story, Triptolemus Yellowley, is continually attempting to introduce so-called improved agricultural methods into the islands, and is the author of many other similarly inconsidered schemes, the results always being disastrous. He has a sister who is the meanest of the mean, but also an acute critic. On a certain auspicious occasion he is congratulating himself on the bonny blaze of wood on the hearth, to which his sister retorts that he won't see such a blaze again unless the house takes fire or a coal-heugh is found.

"And wherefore should not there be a coal-heugh found," said Yellowley triumphantly, "I say, wherefore should not a coal-heugh be found in Shetland as well as in Fife [from whence he came], now that the Chamberlain of the Isles has a far-sighted and discreet man [himself] upon the spot to make the necessary perquisitions."

"I tell you what it is," answered his sister, who had practical reasons to fear her brother's opening on any false scent, "if you promise the Chamberlain so many of these baubles we shall not be well settled here before we are found out and set trotting again. If one was to speak to you about a gold mine, I know well who would promise he should have Portugal pieces clinking in his pouch before the year went by."

"And why should I not," said Triptolemus, "maybe your head does not know there is a land in Orkney called Ophir, or something very like it; and wherefore might not Solomon, the wise King of the Jews, have sent thither his ships and his servants? Yes, you shall all of you see what a change shall coin introduce, even into such an unpropitious country as this. Ye have not heard of copper, I warrant, or of iron-stone, in these islands, neither? There is copper near the cliffs of Konigsburgh; ay, and a copper scum is found on the Loch of Swana, too."

And so on. It should be added that Yellowley was not the pirate which provided the title to the story. Eventually Yellowley has to drop his schemes as the inhabitants are derisive of his failures.

REVIEW OF MINING

Introduction. The metal markets continue to be very dull, and consequently mining remains in the doldrums. The trade of the country is, however, tending to improve, following resumption of operations on the conclusion of the coal strike. Thus there is a rather more hopeful feeling in mining circles.

Transvaal.—The agreement reached last month between the Chamber of Mines and the men's unions for a cut in wages of white labour, depending on cost of living, has already had a brightening effect on the gold shares, and in both Johannesburg and London the quotations have recovered slightly from the low level to which they had sunk. The actual working costs have not yet fallen in any substantial manner, but it is fairly clear that the maximum has been reached, and that an appreciable if small fall may be expected before long. As regards cost of supplies, there is at present few signs of reductions ; in fact, the price of dynamite has been raised.

As the new refinery for Rand gold approaches completion, the question is once more discussed of marketing the gold through a local selling organization, instead of sending it to Rothschilds in London. A suggestion has even been made that the output should be sold ahead on contract, thus helping to stabilize the market. We are not sure that this would have the effect desired. The selling of gold to advantage is an intricate and specialized business and requires close touch with all the banking centres of the world.

Rhodesia.—The output of gold during July was reported at 51,564 oz., as compared with 49,466 oz. in June, and 46,208 oz. in July of last year. Returns for July relating to other metals and minerals produced in Southern Rhodesia were : Silver, 12,620 oz. ; coal, 53,967 tons ; chrome ore 730 tons ; copper, 239 tons ; asbestos, 1,775 tons ; arsenic, 7 tons ; mica, 8 tons ; tin concentrates, 1 ton ; diamonds, 22 carats.

At the Lonely Reef, the development of the 24th level is now giving better results than at first. On the north drive, for 60 ft. from 100 ft. to 160 ft. the assay-value averaged $3\frac{1}{2}$ oz. per ton over 40 in. At 165 ft. the value was $6\frac{1}{4}$ oz. over 55 in. ; at 170 ft., $6\frac{3}{4}$ oz. over 51 in., and at 175 ft., $4\frac{3}{4}$ oz. over 64 in.

The admission of Southern Rhodesia to the Union of South Africa is once more being actively discussed by those in authority, although the popular vote last year was overwhelmingly against such a step. The change of view has followed on General Smuts' sweeping victory in the Union election. This victory is taken as a sign that the inhabitants of South Africa are now following a man who can think imperially and at the same time unselfishly. Louis Botha was a man of the same character, but did not have the extensive support of the Dutch citizens as Smuts now has. It is probable that under the new conditions Rhodesia may join the Union.

Some particulars are given under the heading "Geological Investigations in Rhodesia," in the Mining Digest this month, of the chrome deposits, recently discovered, which have already had such an effect on the market for this mineral. The article also gives some information relating to mica and graphite deposits.

West Africa.—The first return of the Goldfields of Eastern Akkim gave 85 oz. from 4,000 cubic yards. This was effected by a trial run of the new sluicing plant. At the par value of gold the yield was at the rate of 20d. per yard. Investigations are now in hand relative to the working of the ground by dredges.

Nigeria.—As will be seen from the report quoted elsewhere in this issue, the Ropp Tin company was not able to make a profit during 1920, in spite of its large output of tin concentrate, 1,017 tons. During the current year, the costs have been substantially reduced, and the company is now able to make a profit when the price of the metal is above £150 per ton. Mr. Edmund Davis, the chairman, believes that the price of tin will considerably improve after the end of the year, and he is not disposed to suspend operations in the meantime, as such a policy would entail expenses while working is stopped, and also in the subsequent reopening. The company's proved ground is estimated to contain about 10,000 tons of cassiterite.

Australia.—Further information has been given by the British Government with regard to the Australian zinc concentrates purchased. The total quantity held on March 31 of this year was 573,685 tons, while 11,943 tons was

delivered in April, 14,085 tons in May, 16,677 tons in June, 17,758 tons in July, and 22,418 tons in August. It is admitted that there is no prospect at present of disposing of the stocks at prices equivalent to the original purchase cost.

Cable advices give the results achieved by the Broken Hill Proprietary during the year ended May 31 last. The lead-zinc-silver mine was reopened on November 10, after the cessation of the strike, but was closed early in January owing to the unsatisfactory state of the metal markets. During the time of operation 3,875 tons of ore was raised, from which 801 tons of lead concentrate was obtained. The zinc plant gave 2,918 tons of zinc concentrate, the regrinding plant 557 tons of lead concentrate, and the slime flotation plant 1,487 tons of lead concentrate and 4,258 tons of zinc concentrate. At the iron and steel works the output of pig iron was 226,760 tons, and the open-hearth furnaces produced 209,458 tons of steel. A third blast-furnace was blown-in last month.

Alluvial gold has been found on Block 41, owned by Hampton Gold Mining Areas, Ltd., the reconstruction of Hampton Uruguay, Ltd. This is situated farther to the north-east of Hampton Plains than the Celebration and other discoveries of two years ago. It is close to the Trans-continental railway, at about 37 miles from Kalgoorlie. Mr. H. J. Daly, the manager, reports that the find is encouraging, though it does not justify a rush. The district has been proclaimed as a new goldfield, which is officially given the name " Transfind."

Malaya.—The arrangement between the Federated Malay States and the Dutch East Indies with regard to the sale of stocks of tin is to be continued. In February last it was agreed that neither should sell its stocks, purchased in the interest of the local industry, for a period of three months. In May the period was extended by another three months ending August 31. The present renewal of the agreement does not mention any date limit, so apparently the respective Governments do not expect any immediate chance for disposing of their stocks without further upsetting the tin market.

Cornwall.—The directors of East Pool have issued a circular relating to the policy which has become necessary since the collapse of the main shaft. As a matter of fact it is not a new policy, and the accident only had the effect of hastening the proposed modification in the method of attacking the ore. The circular reminds shareholders of the announcement made at the last general meeting that rich ore had been developed on both the Great lode and the Rogers lode, in the Agar section, in the direction of Tolgus, and that the sinking of a new shaft had become necessary. The fall of ground in May occurred over an extensive area in the old workings at East Pool. Although this fall affected the East Pool shaft at the 130 fm. level, and put out of action the electric pumps at the 80 fm., 180 fm., and 240 fm. levels, it was hoped then that the shaft could be repaired. However, continual further falls took place all through the month of June, completely wrecking the shaft and depriving the mine of its winding facilities. During July dams were completed in the cross-cuts to the Rogers lode, in order to isolate that lode in the Agar section from the old workings in East Pool, and salvage operations took place to remove the electric pumps and other material. There was then no alternative but to stop pumping and definitely abandon the old workings at East Pool, as the amount of water was greater than could be dealt with by the Cornish pump, and practically all the ore had been already worked out in this section. The directors have now decided that the new shaft referred to at the general meeting shall be at once taken in hand, and the position of the shaft has been definitely fixed at a point north of the present Agar shaft, where it will cut the Rogers lode at a vertical depth of about 250 fathoms. This shaft will be a combined winding and pumping shaft, and its position will enable it to be used for working the whole of the rich unexhausted portions of the Rogers lode to the west, and the undeveloped portions of that lode to the east in the direction of Tolgus, and also the rich lodes proved by bore-holes parallel to the Rogers lode. The directors say nothing about any arrangement with South Crofty with regard to the underground water question. The point is that when the East Pool pumps are out of action the clearing of the water falls entirely on the South Crofty pumps, which are not equal to the duty. If the newer part of the East Pool company's property is sealed off from the old property, South Crofty will never in the future receive any assistance from the East Pool pumps. There seems to be no alternative for South Crofty but to provide additional pumps.

Canada.—Our Toronto correspondent refers to the prosperity now being enjoyed by the Porcupine gold mines. At the McIntyre, an ore-body 30 ft. wide and assaying $20 per ton is being developed at the 1,375 ft. level, and the mill is to be extended so as to bring the capacity from 500 to 1,000 tons per day. A. Mitchelson and Co., Ltd., of London, has acquired a controlling interest in the Davidson Consolidated, north-east of Porcupine.

United States.—The position of the zinc industry is reflected in the figures of production and export during the first half of 1921. There was produced 100,781 tons from home ores and 1,744 tons from imported ores, making a total of 102,525 tons. These figures compare with 205,269 tons during the second half of 1920, and 258,108 tons during the first half. The stock at June 30 was reported at 94,747 tons, as compared with 71,037 tons at December 31, and 29,892 tons at June 30, 1920. The exports during the first half of 1921 were 2,255 tons, and the imports 7,405 tons. The imports are as a rule nothing at all, while during the immediately preceding half-years the exports were, respectively, 24,500 tons, 99,750 tons, 68,600 tons, and 77,600 tons. The figures here quoted indicate the present demoralization of the United States zinc industry.

Interest in the shares of the Arizona Copper Company has been revived by the statement that the deal with the Phelps-Dodge Corporation is at last nearing completion. In America the purchase of the properties by the corporation is generally accepted as an actual fact, and that only details of price are wanting to complete the transaction. It is presumed that the railway controlled by the Arizona Company will become part of the El Paso and South-Western system, and that the lighting and power service will be transferred to the Phelps-Dodge power house at Morenci, where Diesel engines give cheaper generation of current. It is stated that Mr. J. P. Hodgson, formerly manager of the Detroit Copper Co., is to be appointed manager of the Arizona Company's property.

The Alaska Gastineau Company, operating the Perseverance gold mine behind Juneau, has finally decided to suspend operations. In a lengthy article published in May, 1918, we reviewed the unfortunate position of this and of the Alaska Juneau company, which works a mine on the same line of lode. The Gastineau was controlled by the Jackling group, and the Juneau was an appanage of the Alaska Treadwell group. Both companies suffered owing to the low-grade ores proving far poorer than was estimated, while at the Juneau the milling plant, which was built to a new design, was not successful in practice. The cost of treatment turned out eventually to be much higher than was estimated, but this fact was, of course, beyond the control of those responsible. At the Gastineau it was originally estimated that 21,000,000 tons of proved ore averaged $1·75 in gold per ton, while the probable and partly developed ore was estimated at 75,000,000 tons, averaging $1·50. The operating cost was put at 75 cents per ton and the loss in tailing 25 cents per ton. Almost at once it was found that the average content had been over-estimated, for the first year's results showed an average assay-value of $1·15 per ton and an extraction of 93 cents. At first the cost was 69 cents per ton, but as harder ores were milled the cost of mining and treatment became greater, and at the same time war conditions sent up the cost of labour and supplies. As recorded last year, the position eventually became impossible, so that the recent decision to close down was not unexpected. During the time the mill was at work 11,711,314 tons yielded gold worth $9,508,168.

Mexico.—The Mexican Minister of Finance has made a compromise with the representatives of the United States oil interests, and his action has been approved by President Obregon. The result is that operations have once more been resumed, and the export tax has been withdrawn. The exact terms of the agreement have not yet been made known.

Russia.—The visit of Mr. Leslie Urquhart to Moscow is an important event, and hopes are high that he will be able to make some arrangement whereby the mines of the Russo-Asiatic Consolidated can be reopened. He leaves on his return on the 13th.

China.—The Eastern Pioneer Company, which has done so much good work in prospecting in Sze-chuan under the control of Mr. Pritchard Morgan and by the mining advice of Mr. H. W. L. Way, is being amalgamated with the Yang-tse Corporation, and additional capital is to be raised. It will be remembered that Mr. Way gave an account of the potentialities of this district in the MAGAZINE for July, 1916.

TRINIDAD:
A REVIEW OF ITS GEOLOGY AND OIL RESOURCES

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In the following article the author summarizes our present knowledge of the geology of the Island of Trinidad, with special reference to the mode of occurrence and storage of its oil. An account is given of the progress of development of the petroleum resources, and some of the more important technical difficulties encountered during oil exploration in the Island are discussed.

Introduction.

At the request of the Editor of The Mining Magazine, and also in response to the repeated suggestion from several sources, I have endeavoured in the following paper to present a concise account of the pure and economic geology of Trinidad, an account summarizing more especially our scattered knowledge of the important oil-fields extant in the island.

For its size, Trinidad possesses a really undue share of geological and structural complexity, and as is well known, controversial tectonic questions and stratigraphical problems make up no insignificant part of this somewhat striking feature. Notwithstanding the great amount of prospecting carried out in the past, it is surprising how little is really known of the geology of this island, and although it may appear paradoxical, the more geologists who visit the colony, the less we seem ultimately to know about it; this is a natural outcome of the tendency, both past and present, towards the elucidation of local geological features often without possible regard for the wider potentialities of the work; such localization is the unfortunate concomitant of oil-finding where private and not national interests are the first consideration, and in itself, of course, in no way reflects on the standard of the work carried out hitherto. Scientifically we may deplore the traditional lack of cohesion between geologists who serve solely the interests of different and possibly rival oil companies, and though we may agree strongly with Professor P. Carmody in advocating "team work" in the field as conducive to the best economic results for all concerned,[1] the fact still remains that most oilfield investigation is regarded primarily in the light of a confidential inquiry, whose evidence is stored up in the secret archives of the company responsible for its inception. This practice, while probably necessary in certain cases, obviously inhibits the grasp of the facts by a larger public, and it further retards, through lack of publication, the progress of geological knowledge of the island, a factor which is bound to be detrimental to the best economic development of its natural resources in the long run.

It is not surprising to find, therefore, that Trinidad only has a scattered and incomprehensive geological literature compared with many other oil-producing colonies, and in view of the very general interest evinced in the island at the present time, some coherent account of its geology and oil technology may not be out of place.

Physiography.

Trinidad lies just off the north-east coast of South America, from which it is separated by the Gulf of Paria, the distance measured from mainland to island (across the Dragon's Mouth) being about 12 miles. Both physically and structurally it is related to the South American continent, more particularly to northern Venezuela, whose tectonics are referable to those of the sunken Antillean continent now beneath the Caribbean Sea.[2] Trinidad forms the southernmost peak of a submerged mountain chain now represented by such islands as Antigua, Barbados, and Tobago, the chain constituting the middle Caribbean zone of folded sediments, as defined by Suess.[3] The trend of this chain is parabolic, with concavity facing west, and the island itself marks the turning point of the southerly limb of the curve as it swings round from N.E.-S.W. (Tobago) to E.W., the dominant strike of the Northern Range of Trinidad and of the Caribbean Hills of Venezuela.

Roughly quadrangular in outline, though breached by the sea, particularly on the west coast, Trinidad has a total area of some 1,750 square miles, and a coastline of 220 miles long. Geographically it presents

[1] "Trinidad as a Key to the Origin of Petroleum" Inst. Pet. Tech., May 10, 1921.

[2] H. B. Milner, Oil Resources of South America, *Mining Mag.*, April, 1921, p. 203.

[3] E. Suess, La Face de La Terre, Tome 1, 1897, p. 724 et seq.

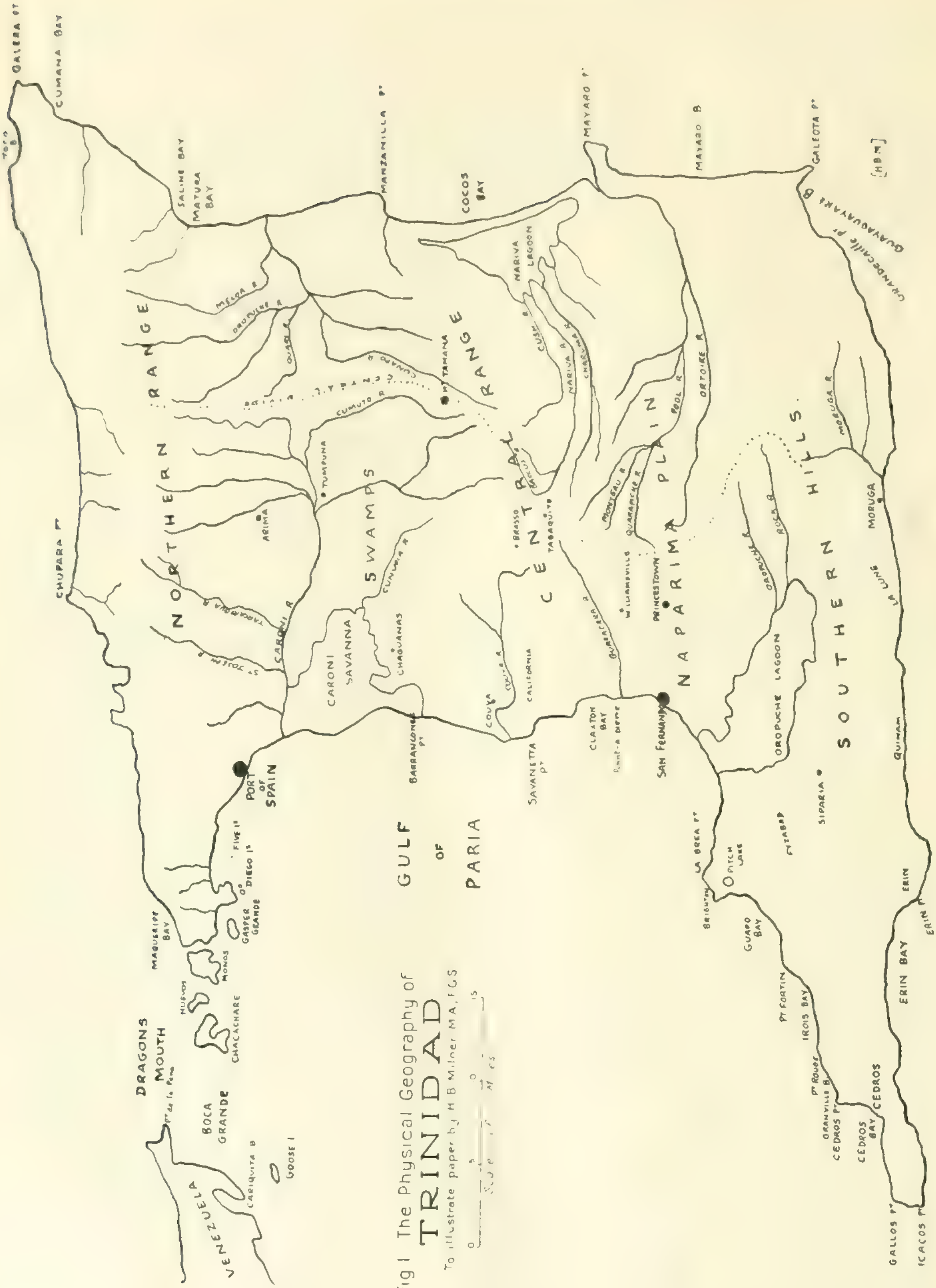


Fig 1 The Physical Geography of TRINIDAD

To illustrate paper by H B Milner MA, FGS

five well differentiated elements: (*a*) the Northern Range, (*b*) the "Swamp" area, forming the basins of the Caroni and Oropuche rivers, (*c*) the Central Range, (*d*) the Naparima Plain, and (*e*) the Southern Hills. The geological significance of these features will be apparent ultimately; for the present we may briefly note the physical characteristics of each.

(*a*) The Northern Range consists chiefly of two well-defined ridges, a foothill ridge with an average height of 800 ft., bordering the north coast, and an inland ridge rising to a height of 3,000 ft. in places. Both ridges stretch almost continuously from west to east coasts, having a total length of 53 miles. The range is tectonically connected with the Caribbean Hills of north Venezuela, of which it is but an eastward extension, the islands of Chacachare, Huevos, Monos, etc., constituting the intermediate links.

(*b*) The "Swamp" area is a typical savanna feature, reminiscent of similar though much more extensive river basins of the northern part of South America; it is formed by the drainage of the Oropuche river flowing east, and by that of the Caroni flowing west; a low watershed separating the two basins rises to a height of 220 ft., and is part of a sinuous divide, traceable at intervals across the island from north to south.

(*c*) The Central Range is composed of a series of comparatively low ridges stretching somewhat irregularly from Point-à-pierre on the west to Cocos Bay (south of the El Branche river) on the east; the average height of the range is about 850 ft., but it includes such hills as Montserrat, Tamana, and Mount Harris, all over 900 ft. high. The ridges are not continuous across the island, but are intercepted by valleys and ravines in which there is an abundant growth of tropical vegetation; the higher elevations are commonly well wooded, particularly in the west. A peculiar feature is the radial development of small ridges from Montserrat itself, five of which strike obliquely to the general E.-W. trend of the range, occasioning much irregularity of topography, characteristic of the western area.

(*d*) The Naparima Plain defines the region between the Central Range and the Southern Hills, and has an average breadth of 18 miles. Its character is that of a gently undulating plateau, occasionally broken by steep-sided valleys and monadnocks such as Naparima Hill and Dunmore Hill. Towards the east the plain becomes flatter as it approaches the swampy tract of the Nariva Lagoon.

(*e*) The Southern Hills are much less clearly differentiated than the other ranges to the north, and are not so conspicuously continuous across the island. One ridge occurs to the east of the Moruga river, stretching from Grandecaille Point to the Moruga valley; west of that valley the country rises again in the form of a broad elevation trending in a westerly direction to Siparia. The principal summits occur in the east, the Three Sisters, for example, rising to heights of over 700 ft. In the west the elevations are slighter, being seldom more than 250 ft. above sea-level. Mainly on account of the arenaceous character of the rocks involved, the hill slopes are often remarkably steep, especially in the eastern part of the range.

From the map (Fig. 1) it will be seen that the main drainage of the island is towards the east and west coasts, the principal watersheds being those of the Caroni, Oropuche, and Ortoire rivers; a portion of this drainage, however, finds its way into swamps such as the Oropuche and Nariva Lagoons, which are low-lying tracts of country bordering the west and east coasts respectively.

The climate is tropical, with a wet season from June to December, when the swamp areas are often quite inaccessible and the rivers impassable. The tropical heat, however, is frequently ameliorated by the prevalent trade winds, and where the principal hill ranges occur the conditions, even in the hottest and most humid months of the year, August and September, are not too trying.

On the lower slopes of the hills and in the plains, the soil is wonderfully fertile and the vegetation is accordingly luxuriant; much of this land is at present under cultivation.

The usual types of tropical fever prevail in the island, but the consensus of opinion shows that, with ordinary precautions, such risks can easily be minimized.

General Geology.

The original geological survey of Trinidad was instituted in 1855 by the Secretary of State for the Colonies, Sir William Molesworth, who was instrumental in

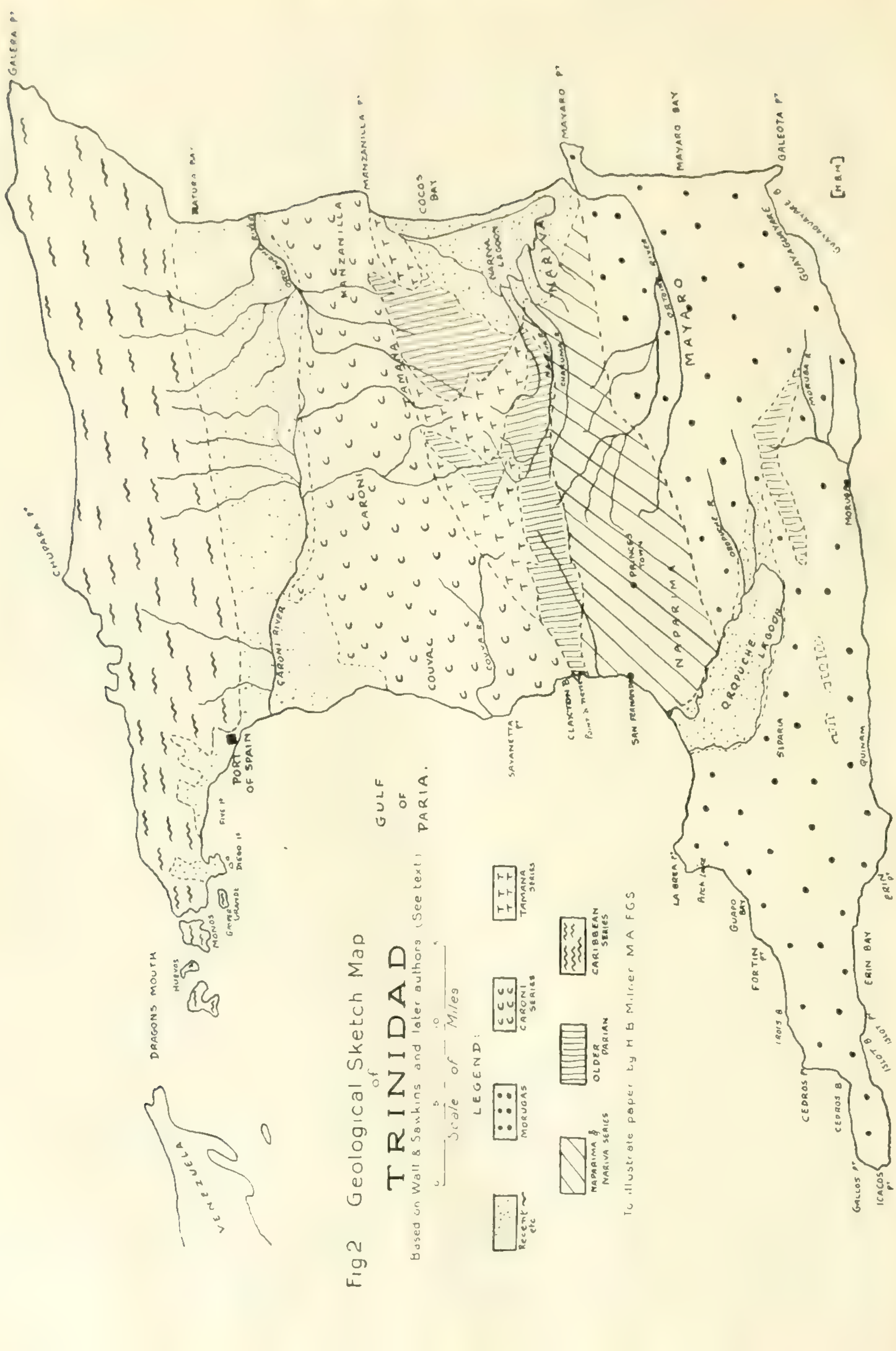


Fig 2 Geological Sketch Map of TRINIDAD

Based on Wall & Sawkins and later authors (See text)

To illustrate paper by H B Milner M A F G S

obtaining Treasury sanction for this and for the scientific investigation of other West Indian colonies. It was Murchison who had the task of selecting a suitable staff, and as director-general of the Geological Survey he appointed G. P. Wall as chief geologist, a former pupil of the Government School of Mines, at that time established in Jermyn Street. J. G. Sawkins, a fellow of the Geological Society and a man already known from his work in Mexico and Cuba, was also recommended by Murchison to accompany Wall, and in this way the classic survey of Trinidad by Wall and Sawkins came to be inaugurated. The work was actually carried out during the years 1857 to 1859, and in 1860 the "Report on the Geology of Trinidad"[4] was issued jointly by those geologists as a memoir of the Geological Survey. This memoir, now both long out of date and print, formed the basis of much of the subsequent economic work in the island, and although later researches have modified much of the geology therein described, the general principles enunciated by the authors still maintain a certain technical value.

Wall and Sawkins divided the rocks of the island into three well differentiated series corresponding approximately with the dominant physiographical elements described in the preceding section; the sequence they established was as follows:—

Tertiary.	3. Newer Parian Group[5]	*a.* Nariva Series. *b.* Naparima Marl. *c.* Tamana or Calcareous Series. *d.* Caroni or Carbonaceous Series. *e.* Moruga or Arenaceous Series.
Cretaceous.	2. Older Parian Group.	
(Metamorphic).	I. Caribbean Group.	

The broader divisions still hold within certain limits, the Caribbean group having its typical development in the Northern Range, the Older Parian group in the Central Range, and the Newer Parian group in the southern part of the island; recent work, however, has modified our ideas of the distribution of the Older and Newer Parian groups because in the Central Range, for example, rocks belonging to the Newer Parian group certainly occur. For purposes of description it is convenient to take this classification as a basis, reserving for future discussion such alterations rendered necessary by subsequent detailed work.

(1) The Caribbean Group.—This group comprises a large and heterogeneous series of rock types in which mica schists, quartz schists, crystalline limestones, and foliated quartz and felspar rocks occur together with less deformed sandstones, shales, quartzites, and conglomerates; these rocks have for the most part suffered intense folding and shearing, and the metamorphism produced varies in character, being greater in the western than in the eastern part of the island. Dalton[6] has shown that the series is typically developed on the mainland in the Caribbean Hills of Venezuela; the crystalline limestones of eastern Venezuela correspond lithologically to the similar facies occurring in western Trinidad (Levantille Hills), and the mica schists and graphitic schists of the former country are recapitulated in many of the highly foliated rocks of the north-west coast of the island. The connecting islands of Chacachacare, Huevos, and Monos, between Trinidad and the mainland, are also composed of rocks of this series, and they represent partially submerged summits of the mountain mass forming the southern border of the ancient "Antillean Continent," remnants of which are now extant in the Caribbean Hills of Venezuela and the Northern Range of Trinidad.

With regard to the geologic age of this group, considerable difference of opinion prevails. Wall and Sawkins are discreetly reticent on this point, though they suggest a "remote" origin; Ells[7] remarks on their lithological resemblance to Huronian or possibly Lower Cambrian rocks in Canada, but the subsequent discovery of some rather doubtful fossils (alleged to be *murchisonia* and *favosites*) in the limestone of the Levantille Hills is certainly suggestive of a Palæozoic age, a point receiving some support from Dalton, who assigned the Caribbean series of the mainland to at least early Mesozoic, Palæozoic, and possibly

[4] For Her Majesty's Stationery Office: published by Longman, Green, Longman, and Roberts. 1860.

[5] Subdivisions of this group *not* arranged in stratigraphic order.

[6] L. V. Dalton, *Geol. Mag.*, 1912, pp. 203–10 and references.

[7] R. W. Ells, Trans. Roy. Soc. Canada, 1907, section iv, p. 117.

Archæan epochs. The latest view is that of Cunningham Craig, who regards the group as Jurassic (not older) or possibly merely altered Cretaceous.[8] It would seem, however, that the balance of opinion at the present time favours a Palæozoic age, though doubtless younger rocks are represented as in Venezuela.

The thickness of the group is another unknown factor, though Wall and Sawkins' estimate of 10,000 to 12,000 ft. is probably highly exaggerated; folding on such an extensive scale as has operated here is bound to produce much faulting and repetition of beds, and Cunningham Craig's computation of the real thickness as being not more than 2,000 ft. is probably far more correct.

(2) Older Parian Group.—As originally described, this group embraces a series of sandstones, clays, carbonaceous shales, and limestones, and also a peculiar deposit known as "argiline,"[9] a siliceo-calcareous claystone, typically developed at San Fernando Hill. The coast section at Point-à-Pierre exposes several facies of this series, and the dark-grey clays and shales with their ferruginous concretionary bands give rise to a very distinctive reddish soil, traceable for some distance inland. The group as a whole is characteristic of the Central Range of the island, extending from the east to the west coasts; it also forms the cores of several hills in the Naparima area such as the Mont Chagrin, Dunmore, and San Fernando Hills, and outcrops in several places from beneath the Tertiary deposits along an elongated tract of country bordering the south coast.

In many instances the rocks show the result of extreme folding, which took place prior to Tertiary deposition. Fossils are peculiarly scarce and the evidence as to geological age is based on lithological similarity to beds at Cumana, Venezuela, which contain definite Neocomian species. Recent work has shown that these deposits in Trinidad may be in part Tertiary, but their accurate delineation both as regards stratigraphical age and geographical distribution can only be settled by very careful detailed survey. This question of age has an important bearing on the geology and prospects of the Tabaquite and Piparo oilfields.

[8] E. H. Cunningham Craig, Geol. Structure of Trinidad, Victoria Inst. of Trinidad and Tobago, 1905.

[9] The argiline is now regarded by some workers as being of Tertiary age.

(3) Newer Parian Group.—The subdivisions of this group quoted above are based on lithological differences, and do not represent successive stratigraphical horizons; the differentiation of the rocks in the field has presented problems of the greatest complexity owing to their heterogeneous characters and varying developments. An explanation of the occurrence of the several facies of Tertiary deposition (and more have been recognized since Wall and Sawkins originally described the group) is to be found in extensive lateral variation, consequent on the existence of different physical conditions under which they were deposited; the sediments were laid down on a (presumably) Cretaceous land surface, in most cases unconformably, and with marked overlap; as a result of the differential erosion of that land, and also as a result of collateral earth movement with sedimentation, deep water, shallow water, and estuarine deposits were formed contemporaneously, and thus a variety of rock types were evolved.

These beds occur on both sides of the Central Range, though their maximum and most important development is in the southern third of the island. The Tamana and Caroni series are typical of the northern region, and the Nariva, Naparima, and Moruga series of the southern region. It is the geological range of the individual series and their correlation, even over comparatively small areas, which have constituted the chief analytical problems in the field, and as these rocks contain the main oil-producing beds at present known in the island, their correct interpretation is a matter of supreme economic importance.

(*a*) *The Nariva Series.*—As originally defined, this series consists of clays, shales, and occasional limestones, yielding a characteristic reddish soil; the rocks are traceable from the west (Naparima) to the east (Nariva) at intervals, but their relations to the Older Parian series are obscure. In the western area the Nariva series is represented by the San Fernando sandstone series, consisting of sandstones, clays, and silicified marble; they are here overlain by the Naparima Marls.

(*b*) *Naparima Marl.*—Typically developed in the Naparima plain and presenting at least three well-marked facies, an older marlstone series resembling massive chalk and including intercalations of clay and foraminiferal sands, a later nodular

calcareous sand, massive and unbedded, containing *globigerina*, *nummulina*, and other foraminifera, and an uppermost green clay; these facies have been chiefly recognized in the western area. This marl series is succeeded by a thick series of clays, the Naparima or Globigerina Clay, consisting of buff-green and bluish-green clays with a glauconitic sandstone at base and top. In age the Naparima marls probably range from late Eocene to early Miocene, the overlaying clay series being regarded as Miocene.

(*c*) *Tamana or Calcareous Series*.—Wall and Sawkins include under this heading the massive limestones of Tamana and Montserrat, with their associated sands and shales, developed on the northern side of the Central Range and alleged to be unconformable to the Older Parian wherever they occur. Guppy has described their lithological and palæontological characteristics,[10] and has shown that the limestones contain several new species of Tertiary mollusca. These limestones seem to form the base of the series and they are overlain by sands, shales, and conglomerates of estuarine origin.

(*d*) *Caroni or Carbonaceous Series*.—This series was originally differentiated as typified by the rocks exposed in the coast section between Manzanilla and Oropuche on the eastern border of the island. Wall and Sawkins recognized a lower non-carbonaceous division consisting of shales, clays, and sands, and an upper carbonaceous series of sands, shales, and coal seams, chiefly met with on the western coast. The geological age of the series is doubtful, Dall regarding them as Oligocene,[11] and subsequent workers as Mio-Pliocene.[12]

(*e*) *The Moruga Series*.—Extensively developed in the southern part of the island, from the south coast to the Ortoire valley. On the whole these rocks have decided estuarine characters and consist chiefly of loose sands, calcareous sandstones, and carbonaceous shales ("lignite seams") as at Point Moruga. At Erin on the south coast the series includes a peculiar "porcellanite," an indurated shale owing its origin, according to Wall and Sawkins, to the (? spontaneous) combustion of associated carbonaceous matter;[13] this rock also occurs at Point Cedros, Point Rouge, and locally at Moruga. The Moruga series is now very generally regarded as being of Pliocene age.

Practically the greater part of the existing divergence of opinion as to the Tertiary stratigraphy of the island is centred in the recognition and correlation of the various members of the Newer Parian group; in the space here available it is impossible to do more than mention one or two of the recent theories, but it may be remarked at once that in the opinion of most workers in the island our knowledge is still insufficient to permit of any dogmatic assertions as to the relative ages and distribution of the beds.

Cunningham Craig regards the Moruga series (as defined by Wall and Sawkins for the southern part of the island) as equivalent to the whole of the Tertiary sequence developed elsewhere, and the Tamana and Caroni series he regards as corresponding to the lower and upper divisions of the Morugas respectively.[14] Again, in the southern area, two distinctive groups of oil-sand have been recognized as the Lower and Upper Galeota groups; their precise horizons have been doubtful, but the same author considers them as being of lower Tertiary age and as representing the lower part of the Morugas. Cunningham Craig's middle Tertiary embraces the middle Moruga series, which includes the Naparima clay and marl series, of Oligocene age according to Dall,[15] but of Miocene age according to the first writer.[16] The typical Moruga sands, lignites, and porcellanites, together with the La Brea oil-sand, constitute the uppermost horizons of the Moruga series, and are assigned by Craig to a late Miocene or early Pliocene age.

Again, during the course of oilfield development, a great many local names have come into existence designating certain sands or particular horizons of economic importance in the Tertiary series. In this connexion mention may be made of the "Morne L'enfer sandstone," "Forest Clay,"

[10] R. J. L. Guppy, Q.J.G.S., vol. 22, 1866, pp. 570–93.

[11] Guppy and Dall, Proc. U.S. Nat. Mus., vol. xix, 1896, pp. 303–30.

[12] E. H. Cunningham Craig, Bull. Imp. Inst., vol. 5, 1907, pp. 175–9, and Victoria Inst. of Trinidad and Tobago, 1905.

[13] Wall and Sawkins, op. cit., p. 49.

[14] E. H. Cunningham Craig, Geol. Structure of Trinidad, Bull. Imp. Inst., v, 1907, p. 175, and Victoria Inst. of Trinidad and Tobago, 1905.

[15] Guppy and Dall, Proc. U.S. Nat. Mus., 19, 1896, p. 303.

[16] E. H. Cunningham Craig, op. cit.

Fig 5 DIAGRAMMATIC MAP OF
TRINIDAD
Showing relationship of proved petroliferous areas to main lines of anticlinal folding

0 5 10 15
Scale of Miles

"Forest Sand," and the "Cruse sands"; the first three are typically developed in the Fyzabad and Point Fortin fields, the Morne L'enfer sandstone overlying the Forest Clay which includes the productive Forest Sand, the two latter equivalent to the Naparima series (in part). The Cruse sand is a local development of the lower Tertiary series principally in the south-eastern part of the island, and is possibly the equivalent of the so-called Lizard series of the south-western peninsula.

More recently still, the palæontology of these Tertiary beds has received considerable attention at the hands of Douvillé,[17] Penny, and others ; the work has been largely a study of the foraminifera occurring in the Naparima series, on account of the great economic importance of that series as the chief oil-producing horizon. It would seem, however, that despite this detailed work, correlation of the beds is still far from satisfactory, and more than one doubt has been expressed as to the ultimate stratigraphic and economic value of the results. So many species occurring in these rocks have unfortunately a long range in time and wide distribution in space, and consequently are of little value as indices of any but the broadest divisions of geologic time ; nevertheless, there is no reason why more detailed palæontological work of this description should not yield important criteria, especially if, as our knowledge increases, certain species can be segregated for purposes of precise zoning.

A method of attack in problems of correlation of the sediments over small areas has been successfully employed by V. C. Illing during the course of his work in Trinidad ; [18] the method is based on an intensive study of the petrography of the deposits, and the results have hitherto been most encouraging. Much more attention is now being paid to this hitherto neglected branch of petrology, and in thus bringing new light to bear on the peculiarly complex problems of stratigraphical correlation in the island, it is to be hoped that far-reaching scientific and economic results will eventuate.

Tectonics.

Although some little account of the tectonics of the main groups into which Wall and Sawkins divided the strata of Trinidad appears in their memoir, the information given is exceedingly scanty, and we owe the first real attempt at the elucidation of the structural features of the island to Cunningham Craig, whose work has been published in various Council Papers (Trinidad) and elsewhere.[19]

From the economic standpoint the most important geological structures occur in the southern part of the island, and it is this region which has naturally received the more detailed attention in recent years ; with the development of the Tabaquite oilfield, the Central Range structures have claimed more careful attention, and a great deal of work has been carried out to this end, though little has been made public. The northern area is commercially unattractive, and the structural features are on that account little known except in broad outline.

Reviewing the facts in the light of present knowledge, however, we can recognize in Trinidad at least three dominant phases of earth-movement operative, as far as can be ascertained, in pre-Cretaceous, late Cretaceous, and Tertiary times respectively. The pre-Cretaceous folding involved the rocks now forming the Caribbean Hills of the mainland and the Northern Range of Trinidad ; the evidence shows that this folding was produced by horizontal earth stress acting along a N.N.W.-S.S.E. line, and the production of a series of parallel folds, disposed en echelon, has impressed an E.N.E.-W.S.W. strike on the rocks which gives the dominant character to the physical relief of Northern Venezuela and Trinidad. In the Northern Range there is noticed a strong tendency to the development of "fan-structure" with concomitant faulting and thrusting ; the latter elements have played but a subordinate part in the evolution of the present structures, the marked repetition of strata being a function of folding rather than of dislocation in this case.

The Cretaceous folding affected principally the sediments of the same age, and to this phase of earth-movement we can assign the initiation of the Central Range. It is probable that the movement actually took place collaterally with sedimentation, and there is evidence also that the basin of deposition received a slight tilt in a N.W.-

[17] M. H. Douvillé, Comptes rendus des séances de l'académie des Sciences, t. 164, p. 841.

[18] Lecture before the Geologists' Assoc., March 3, 1916, Abstract 185.

[19] E. H. Cunningham Craig, Bull. Imp. Inst., vol. 5, 1907, p. 175, Victoria Inst. of Trinidad and Tobago, 1905, Council Paper 119 of 1905 (Trinidad 1905), Council Paper 60 of 1907 (Trinidad 1907).

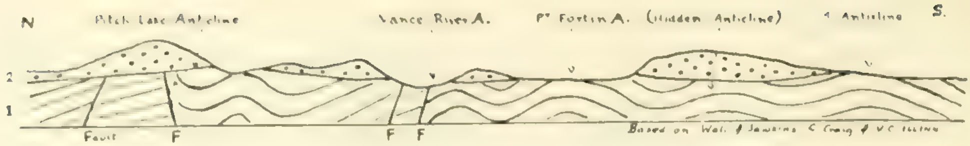


Fig 3 DIAGRAMMATIC SECTION FROM NORTH TO SOUTH ACROSS MAIN ANTICLINAL FEATURES

[1 - Naparima Series. 2 - Moruga Series]

S.E. direction, with elevation towards the S.E. As deposition advanced, the earth movements continued to gather in intensity, and they culminated with the formation of a series of N.E.-S.W. folds, recognizable in the Central Range, and also in the Cretaceous rocks of the mainland. On the whole the degree of flexuring was not so great as in the case of the northern metamorphics, but it was quite sufficient to produce the sharp asymmetrical fold features characteristic of the Older Parian rocks.

Tertiary folding also took place at the time of deposition, reaching its maximum phase towards the close of Miocene times; the early and middle Tertiary deposits were laid down on the eroded Cretaceous land-surface, the sediments becoming involved in flexuring along E.-W. axes, consequent on earth-movement from the south. In this way the Cretaceous N.E.-S.W. folds became modified in the southern part of the island, much as the Caledonian folds are truncated by Miocene uplifts in southern England, and in Trinidad, as in Venezuela and elsewhere, the effect of such tectonic interference was to produce quaquaversal structures, often quite local, but of importance from the point of view of oil accumulation.

Cunningham Craig has shown that the main result of this Tertiary folding was the formation of a well-marked series of anticlines and synclines,[20] in three cases extending right across the island. It is these structural elements with which are associated the principal oilfields of the island, and they may be differentiated as follows (see map, Fig. 5):—

(*a*) The Southern anticline, traceable from Galeota Point to the south-western promontory of the island, in a direction approximately parallel to and bordering the southern coast.

(*b*) The Point Fortin anticline, traceable from Mayaro Bay, along the southern side of Rock River and north of Siparia to Point Fortin.

(*c*) The Vance River anticline, starting from a little north of Mayaro Point and traceable across the basin of the Ortoire River and its tributaries, through the Oropuche Lagoon to Guapo Bay.

(*d*) The Pitch Lake anticline, occurring at La Brea Point and extending eastward along the southern main road.

(*e*) The San Fernando anticline, of doubtful extent, and

(*f*) The Central Range anticline, a less clearly defined feature in the central part of the island.

An intermediate line of flexure occurs between the Point Fortin and Southern anticlines, lying midway between Erin Point and Siparia; although for the most part hidden, it is quite possible that its linear extent may be considerable.

Besides the above-mentioned folds, a great many local and subordinate flexures occur, particularly in the southern part of the island; their individual characteristics are but little known except to company geologists, though in general their relations to the larger tectonic features are evident. The diagrammatic section, Fig. 3, illustrates some of the most important folds.

(*To be concluded.*)

The Iron and Steel Institute held its autumn meeting in Paris during the week beginning September 5. In addition to the usual sessions at which technical papers were read and discussed, a number of excursions were arranged. One of these excursions covered the Lorraine iron ore fields; a second consisted of a visit to the steel works of Creusot and Chamand; while a third was to the iron deposits and industries of Normandy. A reception was given by the Comité des Forges on September 5.

[20] E. H. Cunningham Craig. op. cit.

THE VENTILATION OF DEAD-ENDS IN MINES

By STANLEY NETTLETON, M.Inst.M.E., Assoc.Inst.M.M.

THE desirability of completing the development work of a mine as soon as possible after its inception renders the problem of efficient ventilation a matter of great importance to mining engineers. In addition to the primary consideration of safety of the workmen, the relationship between time and costs must not be lost sight of, for a sinking shaft or heading is generally of no value until completion. The interest on capital expended may amount to a considerable sum.

Blasting operations in "dead-ends" may take place several times daily, and it is desirable that workmen on each occasion should return to the face as quickly as possible consistent with safety.

In metalliferous mining it is a common practice immediately before firing a charge of explosives to open taps on the compressed-air service in the immediate vicinity. This certainly results in the introduction of cool and pure air into the working face, but the disadvantages of this method of ventilation are obvious. Even when a water-blast is employed the discharge of air at high pressure tends to place dust in suspension in the atmosphere, and the cost of removing blasting fumes efficiently may be excessive, as from a pipe 1 in. in diameter there may be discharged 15,000 to 20,000 cubic feet of air per minute.

A working face is frequently well ventilated by the exhaust of machines during drilling operations, but these only occupy a portion of the time when men are engaged in the shaft or drive. In order to maintain the efficiency of labour it is essential that fresh air should be provided in large volumes for dilution of noxious gases and reduction of temperature.

Among the arrangements which have been extensively adopted for the conveyance of fresh air to the faces of dead ends are pipes of large sectional area, and the division of the shaft or roadway into two portions by means of a partition of canvas or other material fixed from floor to roof in a line parallel to the heading. The difficulties associated with the fixing and maintenance of these devices are well known to men on the work. Air conduits of light metal or casings of wood are cumbersome and heavy. The cost of transport, erection, and dismantling on the completion of mine development may be greater than the initial cost of material employed. The removal of rigid air conduits is usually carried out in so hurried a manner that they require the attention of fitters or carpenters before they are fit for further use elsewhere.

With the greatest care in erection, the amount of leakage is apt to be excessive, particularly if the conduits are subject to vibration due to air-blasts arising from the use of explosives. The leakage of air is much greater than is generally realized by those in charge of the plant.

Tests made at the South Star Mine, Ballarat, Australia, showed that on forcing 3,830 cubic feet of air through 3,230 ft. of ventilating pipe 11 in. in diameter only 510 cu. ft., or 13 % was delivered at the face. At another mine in Victoria the relative quantities of air forced into the system and delivered where it was required were 4,630 and 1,136 cu. ft. per minute respectively, an efficiency of 24%. To obtain even moderate efficiency it is essential that with the metal or wooden air-conduits very great care must be taken in installation and maintenance to avoid leakage at joints. Rigid air conduits cannot be carried near a working face where explosives are used without risk of damage from falling rock, and when, as is frequently the case, box-holes have to be opened out on a drive in course of development the temporary removal of ventilation arrangements may be a matter of considerable inconvenience. Metal pipes or wooden boxes 1 or 2 ft. in diameter cannot be readily stored in a roadway where tramming operations are being carried on.

The division of a roadway into two sections for ventilation purposes has several disadvantages. Canvas sheeting extending from roof to floor does not make a very satisfactory joint even at the low ventilating pressures which exist in airways of large sectional area compared with totally enclosed conduits. When increased width of roadway is necessary extra cost is entailed in most instances. Though this may not be a serious matter when the road is entirely in coal or ore-body the question of roof support may demand serious attention. At some collieries in Lancashire these difficulties have been surmounted by building in the centre of the roadway a brick wall, which serves the double

purpose of supporting the girders, sustaining the roof and dividing the road into intake and return airways. This has proved to be an efficient though costly method of dealing with the problem. The erection has to be carefully carried out, and the cost, chiefly due to the amount of labour employed on the work, prevents this method of ventilation from being largely adopted. For general practice the most satisfactory arrangements for the supply of fresh air to dead-ends appear to consist of some form of conduit which has considerable sectional area, is simple in installation, and can be readily removed when necessary. Many attempts have been made to use collapsible canvas conduits designed to comply with the above requirements. In an Austrian device the conduits are rec-angular in section, the canvas being supported by a light frame of wood or metal. Owing to difficulties in manufacture at low cost and risk of leakage at joints which cannot be made satisfactorily when the main has not a regular alignment, this type of ventilating conduit has not been largely adopted. Canvas tubes of circular or oval section offer greater possibilities of success, but the connexion between the individual lengths presents difficulties. The use of half-flange joints coupled by bolts involves the use of a spanner in erection and removal, apart from the disadvantages of cost and weight. Owing to corrosion by acid mine water it may be necessary for the iron connexions to be cut apart, and further cost is entailed in labour for removal of bolts and clamps.

The use of the Ventwal patent joint appears to solve most of the above-mentioned problems. It consists of two oval rings, overlapped by the canvas which forms the air-conduit. The connexion is made by inserting one ring into the open end of another length of canvas. One end is then rotated 90°, so that the two rings are exactly parallel to each other when they are drawn together. The canvas surrounding the metal rings makes an air-tight joint, the efficiency of which is increased by any further tension upon it. Over eleven miles of these tubes have been sold to mining companies in England and abroad. They are made in lengths of 20 ft., and of any required diameter. Tubes of 36 in. in diameter have been supplied to a copper mine in Rhodesia, and five repeat orders were received from an English colliery company last year. They are light, and may be suspended from roof timbers or carried on plugs driven into the wall. The stiffness of the canvas employed prevents collapse, even when working on exhaust pressure, but as the tubes may be used on irregular drives or laid over broken ground, each length of 20 ft. contains four iron supporting rings.

To obtain a rot-proof canvas has been a matter of some difficulty, but the Telephos Co., Ltd., of Vaughan Road, West Harrow, Middlesex, the licensees for the manufacture of Ventwal tubes, have placed on the market tubes of canvas specially treated to render it resistant to the acid water and the deleterious fumes so frequently met with in mining work.

The forcing of air at high pressures through pipes is a most uneconomical and usually a very inefficient method of ventilation. Pressures equal to 20 to 30 inches water-gauge, produced by Roots blowers, have been recorded in details relative to the ventilation of shafts and headings in Australian mines.

Expenditure in installing larger air-pipes would be well justified by reduction in working costs and by improvement in air supply in these cases. The air current should be at as low a pressure as is possible consistent with efficiency of service, and though the use of blowers and fans driven by engines or motors has sundry advantages, a jet of air placed in a pipe of large section has much to recommend its application. It is simple and not likely to get out of order, and where the pressure is within reasonable limits it is remarkably efficient as an injector.

A few years ago tests were made by Mr. E. Pam on the Geldenhuis Deep gold mine, Johannesburg, on a 538 ft. length of 9 in. pipe with four right-angle bends, with the following results, the air pressure on the mains being 72 lb. per square inch :—

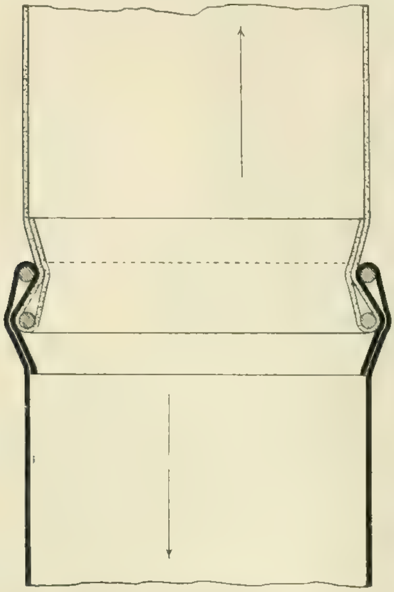
	Size of Nozzle.	Discharge in cubic feet per minute.	Theoretical from Tables. Free air per minute produced by jet.
	in.		
Flange on	$\frac{1}{16}$	210	5
	$\frac{1}{8}$	530	19
	$\frac{3}{16}$	770	43
	$\frac{1}{4}$	1,080	76
Blind flange on intake of pipe	$\frac{1}{4}$	80	Quantity of air actually measured coming out of nozzle.

These practical tests show that the consumption of air from the compressor service is from $\frac{1}{40}$ to $\frac{1}{14}$ of the total amount of fresh air forced through the ventilating pipe.

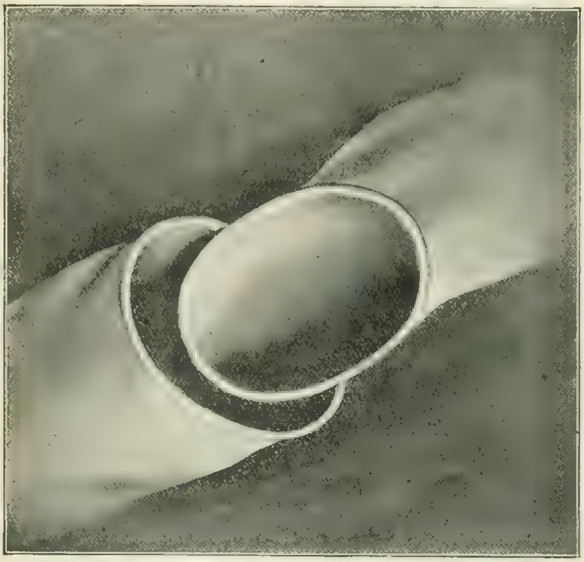
The use of air from the compressor engines as a source of supply, and not of power for ventilation cannot be too strongly condemned.

It is becoming generally recognized that ventilation is a factor of importance in dealing with mining costs, owing to its influence on the efficiency of the worker. Labour costs have increased enormously in recent years, and the miner who is supplied with an abundance of cool and pure air is more likely to do a fair day's work than those who toil in a warm atmosphere contaminated by traces of blasting fumes. Bad ventilation has far-reaching effects. Men not only become inefficient underground, but on reaching the surface in a condition described as "played out" they are ready to listen to any argument in favour of striking for higher rates of pay for work which in the opinion of their employers is costing much more than is reasonable.

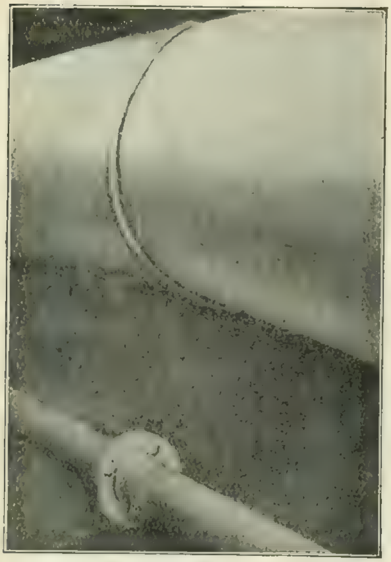
With the exhaustion of the older mines,



SECTION THROUGH VENTWAL JOINT.



MAKING VENTWAL JOINT.



VENTWAL JOINT COMPLETE.

SHOWING HOW VENTWAL TUBING CAN BE PUT THROUGH NARROW AND IRREGULAR FISSURES.

the question of ventilation becomes more important owing to increase of temperature with greater depth of working. It is in development work and in outlying parts of a mine that the ventilation is most likely to be unsatisfactory. In many mining areas these should receive more attention than appears to have been given to them in the past, when high wages and a short life underground were generally regarded as prominent features in the life of the miner. Apart from considerations of health and contentment of employees, which should be regarded as matters of first importance, the influence of good ventilation in the mine on working costs should never be overlooked.

CRUSHING AND CONCENTRATION AT MOUNT LYELL

In our issue of November last we quoted from a paper by Mr. L. V. Waterhouse, describing the flotation plant recently brought into use at Mount Lyell. Since then we have received some notes from the company, giving an outline of the crushing, sorting, and dressing plant, describing the course of the ore through the plant, with special note of the rearrangements introduced for the purpose of saving labour. It will be remembered that the ore from the Mount Lyell mine is pyritic, and low in copper and silica, while that from North Lyell is higher in copper and contains much silica. Some of the North Lyell ore can be picked and sent direct to the smelter, while the rest requires concentration. The ore from the Lyell Comstock all requires concentration.

The first-class North Lyell ore as it arrives from the mine is dumped into the bins reserved for it, as shown in the diagram herewith. From the bins the ore is fed over a grizzly, which screens out the material *minus* $1\frac{1}{2}$ in. in size. The *minus* $1\frac{1}{2}$ in. material falls through a chute on to No. 4 conveyor, which in turn discharges it on to the inclined conveyor No. 5. The latter carries the *minus* $1\frac{1}{2}$ in. material to the top of the mill, where it is distributed over the mill-feed bins by a conveyor.

The oversize, or material too large to pass through the $1\frac{1}{2}$ in. grizzly, falls upon No. 1 conveyor, and discharges over a chute on to a shaking grizzly-feeder, where it is washed and the material *minus* 4 in. screened out. The oversize from the shaking grizzly-feeder is fed into the jaws of No. 1 crusher, which crushes to 4 in. The *minus* 4 in. material from the shaking grizzly-feeder, together with the crushed oversize, falls upon the inclined conveyor No. 6. This raises the crushed and washed ore to the top of the sorting plant, and discharges it on to the sorting belt or conveyor No. 7. The ore on the sorting belt passes in front of the sorters, who pick out the lower-grade material, depositing it in chutes, which discharge on to No. 8 conveyor, and thence into the reject bin. The higher-grade ore is left on the sorting belt, and from there passes over conveyors Nos. 9 and 10 to the sorted ore-bin. From this bin the sorted ore is taken in trucks to the smelter bins.

The reject ore is fed from the reject bin by two reciprocating feeders on to the inclined conveyor No. 3, which serves as a belt feed to No. 3 crusher set to crush to $1\frac{1}{2}$ in. The $1\frac{1}{2}$ in. product from No. 3 crusher falls upon No. 4 conveyor, passes to No. 5 conveyor, and thence to the mill-feed bins, joining the *minus* $1\frac{1}{2}$ in. material already referred to.

The second-class North Lyell ore is delivered into bins as marked in the sketch, and is passed over grizzlies having $1\frac{1}{2}$ in. spaces. The *minus* $1\frac{1}{2}$ in. material falls on to No. 4 conveyor, thence to No. 5 conveyor, and on to the mill-feed bins, to join the $1\frac{1}{2}$ in. material noted above. The oversize falls on to No. 2 conveyor, which serves also as a belt-feed to No. 2 crusher, set to crush to 3 in. approximately. The 3 in. product from No. 2 crusher falls on to No. 3 conveyor, and thence to No. 3 crusher, where it is crushed to $1\frac{1}{2}$ in. The $1\frac{1}{2}$ in. product from No. 3 crusher travels over the same course as noted in the case of the reject ore.

The Comstock ore is delivered to the mill-feed bin, which also receives some of the second-class North Lyell ore. The ore passes over a $1\frac{1}{2}$ in. grizzly directly into the jaws on No. 4 crusher set to crush to $1\frac{1}{2}$ in. The $1\frac{1}{2}$ in. product from the crusher joins

the *minus* 1½ in. product from the grizzly, and is elevated to the distributing belt over the mill bins.

It will be seen from the foregoing that all the ore delivered to the sorting and crushing sections is, after removal of the higher-grade material, crushed to 1½ in. and sent to the mill-feed bins. The combined 1½ in. material is delivered, via two roll feeds and a short cross conveyor, on to a ½ in. shaking screen feeder. The oversize from the shaking screen is crushed and elevated, and returned to the screen, all material eventually having to pass through the screen. The *minus* ½ in. product from the screen is elevated to the feed of the Hancock jig, which makes three products, concentrates, middlings, and tails. The concentrates are lifted in an elevator to a dewatering vat, and from there are taken in trucks to the smelter bins. The middlings are crushed in a set of fine-crushing rolls, the product from the rolls joining the feed to the jig for re-treatment. The tailings are delivered to an elevator and lifted to a shaking screen-feeder having ⅛ in. holes.

The oversize from the screen-feeder is crushed through a set of fine rolls and returned to the screen via the elevator. The *minus* ⅛ in. material passing through the screen is elevated to a diaphragm cone, where the excess water overflows to two Dorr thickeners, and the sandy discharge is fed directly into two tube-mills. The ore, after being ground in the tube-mills, is discharged into the boot of an elevator and lifted to the feed end of a Dorr classifier. In the classifier all material that has been sufficiently crushed is separated from the coarser material, and overflows to the boot of the Minerals Separation feed-elevator. The sandy discharge from the classifier joins the discharge from the cone, and is returned to the tube-mill for further grinding. The thickened slime from the Dorr thickener joins the overflow from the Dorr classifier in the boot of the Minerals Separation feed elevator, and is lifted to the Minerals Separation machines for further treatment.

The ore, which has now been reduced to *minus* 65 mesh, is fed to the Minerals Separation boxes, of which there are twelve. The first eight boxes produce concentrates and tailings. The tailings from the first eight boxes are treated in the last four boxes, where a middling concentrate is produced which is returned to the first eight boxes for re-treatment. The tailings from the last four boxes then pass over a small cascade box, the float from which joins the middling concentrates from the last four boxes for re-treatment. The tailings from the cascade box are sent to the dump. The concentrates from the first twelve boxes are elevated to Oliver and Portland filters, where the excess water is removed, leaving a concentrate carrying from 11 to 15% water. The filtered concentrates fall upon a conveyor that delivers them into a bin, from which they are loaded, weighed, and sent to the smelter for further treatment in the Dwight & Lloyd sintering plant. After sintering the concentrates are combined, in proper proportion with the sorted ore, jig concentrates, Mount Lyell ore, and fluxes, and smelted in the blast-furnaces.

Sorting Plant at Mount Lyell.

LETTERS TO THE EDITOR

The Origin of Primary Ore Deposits

The Editor :

SIR—Mr. Kendall has had wide experience of ore deposits, and I appreciate the compliment of his contributing (in the MAGAZINE for May last) to the discussion of my paper on the origin of primary ore deposits. I regret, however, that his article contains so much evidence that he did not either grasp my views or study my paper adequately.

I made no attempt at "explaining the well-known features of the different classes of ore-bodies." I sought an explanation of how metals are segregated from their original disseminated condition in rock magmas, in what condition of solution they are carried in magmatic liquids, and the causes of their deposition as ore minerals therefrom.

For my purpose drawings were of no value whatever.

In connexion with crust formation and foundering and the differentiation of primeval magma, Mr. Kendall has missed what I say at the bottom of page 9 of my paper : "The crust became permanent long before the capacity of the fused silicates for the absorption of water and oxygen was satisfied, then general absorption was prevented and the molten mass no longer in violent agitation underwent segregation into an acidic portion above and a basic portion below"; also the first paragraph on page 10 : "The top of the crust was probably not truly granitic, but considerably more basic since it was only after its formation that the segregation upward of the acidic sub-magma could have taken place."

I have no means of access here to the records of the United States Geological Survey, and I am not conversant with the work of Barns referred to. Where the fallacy comes in I do not know, but it is obviously incorrect to assert that fragments of any solid can float on a liquid the density of which is less than that of the solid.

That an aqueous mother-liquor is given off by magmas, which, on consolidation, yield granite, is so widely accepted that it seems unreasonable to regard it as anything but a fact as well established as any such process can be. Mr. Kendall says I do not give the evidence on which the "assumption" is based. He has overlooked what appears in the middle of page 7 : "We come to this conclusion on the evidence of quartz and pegmatite veins, one or both of which are invariably found in or above granite batholiths. These veins are not filled with quartz or pegmatite in a state of simple fusion, and there is no doubt that the elements of water were present in the liquid from which they were derived."

I did not assert that primeval granite was derived from diorite. On page 9 we find : "It is probable that the primeval crustal magma was between syenite and diorite in composition, with about 60% of combined silica and without water." The effect of the absorption of water appears to have been to break up certain silicates, especially the ferro-magnesian, freeing silica and bases such as FeO. The former combined with water and, as silicic acid, leached from the magma those silicates most soluble in it, especially those containing potash, and such ore minerals that were present as it could dissolve under the conditions. Those practically insoluble in silicic acid remained behind in the basic portion of the magma ; examples of these are magnetite and chromite. The bulk of the sparingly soluble sulphides were also left behind. Water appears to divide a rock magma into an acid and a basic portion and the ultimate residue is practically non-siliceous ore. Crystallization differentiation and gravitative segregation are both equally incompetent to furnish the force necessary for the dissociation of silicates and the entire removal of silica from combination with bases. There must be some basic radicle present which has a greater affinity for silica than have the bases that are liberated. The only compound present capable of effecting the changes observed in nature I believe to be water, which, as hydroxyl, seems to have a strong affinity for silica.

It appears improbable that primeval magma could have contained free silica. Mr. Kendall asserts that the basic rocks do not contain free bases with which the free silica in granite could have combined originally. It is impossible for us to ascertain the quantity of free bases existing in basic rocks because the great bulk of them is not within our reach. The quantity of free silica in existence is certainly very large, but it makes a great show, for it is a leading component of the lighter rocks forming the greater part of the immediate surface layer of the earth. If Mr. Kendall realizes that the bases in calcium carbonate

and sodium chloride as well as magnetite, to mention only three substances common on the surface, were originally combined with silica, he will probably admit that the conclusion he has arrived at on this subject is not at all a safe one.

If the primeval crustal magma, as I believe, was an anhydrous silicate melt at its commencement it is practically certain that it contained no free silica. When water was absorbed the modification of the affinities of component radicles brought about by the presence of hydroxyl would lead to the formation of many new minerals whose existence was previously impossible, such as the micas. These were not confined to such as contained hydroxyl. It is doubtful if felspars, and particularly the the alkali felspars, could have come into existence in appreciable quantity in an anhydrous silicate melt.

The subject of magmatic differentiation is one on which there is much divergence of opinion, and concerning which it is easy to arrive at false conclusions. It is most regrettable that we have no geo-physical laboratory in Britain, for it is only by means of experiment that we are likely to ascertain the truth.

We now come to the definition of primary ores. While professing not to do so, Mr. Kendall uses the same criterion as I do, namely, genesis, in defining ores. All metals came up in solution in magmas in the first instance. They appear as ores only after magmatic segregation, and all must fall into one of two classes : (1) Those segregating as such within magmas, and (2) those expelled from magmas in solution and deposited usually in fissures either near the periphery or in overlying sedimentary rocks. Mr. Kendall says a primary ore is one " which has not been derived from any other ore." Since such ores must of necessity belong to one of the two classes mentioned above it follows that Mr. Kendall's definition and mine must have exactly the same meaning.

Mr. Kendall asserts that a pressure of 3,000 lb. per square in. would have prevented the expulsion of mother-liquor from the primeval crustal magma. Many granite batholiths demonstrably solidified under a depth of sediments which in hydraulic head only produced a pressure at the periphery much greater than 3,000 lb. per sq. in., yet we have evidence that such magmas gave off mother-liquor in every known case. The expansive force exerted by magmas on solidification is enormous.

Mr. Kendall doubts that magmatic liquids (1) removed the bulk of ore minerals from an acid magma, and (2) were the vehicle in which primary ores were transported to veins. Let us take the case of Cornwall, which is well known to most of us. How much tungsten, tin, or copper is found in components of the granite ? Practically none. Before consolidation of the granite these metals must have been disseminated in solution throughout the magma. It is not possible to explain their existence in the position in which we find them unless we admit that they were segregated by some means from the magma leaving barren granite, expelled in liquid form with silica, water, and other minor constituents in what we call mother-liquor, and that this, under favourable conditions yielded the ore minerals that we find in fissures both in the granite near its periphery and in overlying sediments.

The immediate cause of the development of ore minerals from magmatic liquids is not understood. I have not neglected the precipitating effect of substances in the walls of fissures as Mr. Kendall asserts. I refer to it in the last paragraph under " temperature of deposition " on page 19. Such cases as those cited by my critic are exceptional and no generalization can be based on them.

In Burma we have fissures filled with wolfram and quartz that have been reopened and the new space filled with chalcopyrite and quartz, reopened a second time and filled with pyrrhotite, blende, galena, stibnite, and quartz. This demonstrates clearly that the granitic magma gave off mother-liquor containing not only tungsten, but copper, zinc, lead, and antimony, and that in each case the ore minerals are accompanied by silica. I state this in order to demonstrate that the magma gives off in mother-liquor not only the high but the intermediate temperature ores by the same vent, and the latter in some cases at a later period than the former.

To the first paragraph on page 275 I cannot reply ; it is enigmatic.

In spite of Mr. Kendall having quoted the paragraph in which I define the scope of my paper, he insists on bombarding me with examples of ore deposits of types to which I made no reference. I purposely limited myself to ores occurring in veins

in order to present the problem of ore deposition in its simplest aspect.

Some of the types referred to by my critic, for example, that at Leadville, are probably not primary in the sense in which I use the term. Many galena and other sulphide ore deposits that I have seen I regard as not rigidly primary but secondary, due to replacement that acted in the same way as that by which chalcocite and galena were introduced into sedimentary rocks such as the "Red Beds" of the south-west United States, and Permian and Triassic beds elsewhere.

Concerning the origin of ores in veins in and near the periphery of batholiths, there can be little doubt, but the problem increases more and more in complexity as the deposits are farther removed from their source in igneous rocks. The genesis of ore deposits cannot be studied satisfactorily except by working up from the simplest, near igneous rock, to the more complex at greater and greater distances away. Many deposits usually regarded as primary may be really secondary, the result of metasomatic replacement by ore-bearing solutions produced by the dissolution of primary deposits by agents very different from those contained in magmatic liquids.

Though outside the range of my paper, I may remark, in connexion with some of the examples given by Mr. Kendall, that the present form of vein walls and the composition of vein matter, both as regards ore and gangue minerals, may be very different to-day from what they were when deposited. Many strata containing ores have undergone metamorphism, and it is quite evident that marked alteration, in form and composition of both walls and contents, may have resulted.

J. Morrow Campbell.

Yengan, Southern Shan States,
Burma, *July* 14, 1921.

Manjak

The Editor:

Sir—In your issue of April last, in an article on the "Oil Resources of South America," by Mr. Henry B. Milner, the following statement occurs: "Glance Pitch, a variety of asphaltite, is a natural desiccated petroleum produce, which, when free from mineral matter, is known as 'manjak.'" I hardly think that the name manjak is of such wide application. It is not so used by Clifford Richardson in his treatises on the various hydrocarbons and allied substances, nor by Heinrich Ries, in his "Economic Geology." And is not found at all in the publications of United States Bureau, edited by the late G. H. Eldridge, their recognized authority on the hydrocarbon series.

As a matter of fact, the term manjak originated in the island of Barbados, and was never used outside that area until the neighbouring island of Trinidad struck a grade of glance pitch to which the Barbadian term was promptly applied, paying us the compliment of this sincerest flattery. The term is as distinctive of certain particular grades of glance pitch found only in Barbados, as is the term "Demerara crystals" of a particular class of sugar, and that notwithstanding the adoption of it by Trinidad, whose product does not enter into competition with that of Barbados. To the trade, the products are known as "manjak" and "Trinidad manjak."

Although manjak does claim to be of great purity (and in a report on it by the Mineralogical Bureau of Bohemia, it is stated of one of the grades that "it is surprising to find a bitumen of such purity in nature"), yet it does not claim to be "free from mineral matter." In fact, Mr. Milner seems to contradict himself when he applies the term to a product of South America, which he states "contains *only* 3% of mineral constituents."

R. H. Emtage.

Ellerton, Barbados.
July 13.

BOOK REVIEWS

Oil Land Development and Valuation. By R. P. McLaughlin. Cloth, octavo, 200 pages, illustrated. Price 18s. net. New York and London: McGraw-Hill Book Company.

There are comparatively few phases of the mining industry calling for such specialized knowledge and technique as oil land development, and those who are unfamiliar with the vicissitudes of oil production can form but a small idea of the difficulties and responsibilities entailed in "running" a field successfully, the unenviable task of the average field manager. If things go wrong, as they may often do, there are two parties upon whom the blame may be conveniently fastened by inexorable directors, the geologist and the field manager; the former bears the initial brunt of adverse criticism if his

locations of well sites prove unprofitable; or if an unkind fate decrees the absence of oil at anticipated horizons; the latter, once some wells are brought in successfully, has to look to his laurels should drilling contractors give trouble, production slacken, or unaccountable failure overtake the operations of the company concerned. In either case the lot is not an easy one, and reputations are speedily made or broken as chance decides. The geologist, however, has an advantage, in that public opinion has of late been much enlightened by an extensive literature describing his work, which, intelligently perused, has brought home to the uninitiated some of the difficulties he has to face; the field manager and those who, with him, share the responsibility of development and production, have few volumes accurately descriptive of their work, and consequently less is known generally about such matters as well-drilling, water and gas troubles, cementing, casing, bailing, and shooting wells, output charts, production reports, and the like. The reason for this is not far to seek; competent field management is only won by long experience, and the nature of operations in different fields is often so variable that probably no single exposition by any one author would be adequate to all cases. Yet Mr. McLaughlin has undoubtedly given us a book which presents this aspect of the oil industry in a most concise and practical manner, and this volume cannot fail to be of the greatest use and enlightenment to all concerned with the development and successful administration of oil properties.

The author was formerly State oil and gas supervisor of California, and the foundations of this work are laid chiefly on experience gained in Californian fields; those who know anything about the technology of these oilfields know how diverse are the conditions of oil occurrence in that region, so that the author's contention that the principles involved in oil production there are applicable to all oilfields, though a somewhat sweeping statement, is one with which few will disagree.

The various phases of oil land development and valuation are grouped together under six main sections dealing successively with development programmes, drilling of wells, underground information derived from well-logs, oil production, repairing, deepening and abandoning wells, and values of oil properties. In all cases the principles involved are clearly discussed and some excellent diagrams appear in the text in illustration of the ideas involved. The ten sketches depicting flooding of oil wells by water, due to various causes, are especially good (Chapter II), and our only criticism in this connexion is that there might be more figures like them (publishing costs permitting!) explanatory of other possibilities of bad wells. The author has a good deal to say on sampling wells, that most important branch of drilling; he agrees with most observers in remarking that cable tools on the whole yield better samples than rotary, but he rightly draws attention to many difficulties in the way of procuring representative samples of strata, no matter what system is employed. In view of the increasing importance of microscopical investigations of the materials brought up, from both petrographical and palæontological standpoints in identification and correlation of horizons, it is to be hoped that manufacturers and others engaged in the production and manipulation of drilling plant will keep this in view, either perfecting existing sampling devices or so modifying the commonly used bailer for the collection of cleaner and less contaminated material than is customarily obtained thereby.

In the paragraphs on assembling of information, the construction and analysis of well records are discussed, and graphic well logs explained; an interesting feature is the use of "peg models," that is, models of wells of a given field made of wooden rods fixed into a firm base, the rods being coloured in sections representing thicknesses and differences of strata passed through; correlation of horizons from one well to another is effected by using fine string, and thus the structure of the field and the differentiation of producing horizons may be usefully portrayed. Such a model exists of the Coyote Hills Oilfield, California, and is here illustrated (p. 71).

The remainder of the volume calls for little remark, save that the final chapter on the value of oil land is somewhat brief in proportion to its importance; several references are given, however, to other and more detailed works published in America.

Of all the various works published hitherto on oil technology, there are just four of particular merit which we should like to see compulsorily laid on every petroleum company's board-room table; Mr. McLaughlin's volume is one of the "big four."

H. B. Milner.

Manganese. Pamphlet, 151 pages. Price 3s. 6d. net. London: The Imperial Mineral Resources Bureau.

This is a report, one of a series, dealing with the mineral industry of the British Empire and Foreign Countries, and published by the Imperial Mineral Resources Bureau.

While manganese minerals and alloys have been necessary in steel manufacture since the introduction of the Bessemer process, they became important factors to the Allies during the war period, by reason of the difficulty of obtaining supplies of the raw material, consequent on the activity of submarines, and also because no equally efficient deoxidizer of the steel bath was available.

Since 1913 much information has been published on the subject, particularly in the United States, and the monograph is a painstaking and complete compilation of this material with that previously published considered of sufficient interest to include in the publication.

The value, however, of a volume like the one under review is somewhat reduced by the fact that the information is not contemporaneous, and represents the viewpoint of many different observers. These disadvantages are evident when dealing with economic details, some of which, owing to being somewhat out of date or relating to the war period, have a reduced present or future value ; and also when discussing estimates of ore reserves.

The preface indicates that the volume will be published annually, and it is hoped that with the help of the Foreign Commissioners of the recently created Department of Overseas Trade, as well as of our Diplomatic and Consular representatives, it may be possible in future to publish reliable statistical and economic information shortly after the period to which it refers, in addition to that of a more general character which appears from time to time in the proceedings of scientific institutions and in the technical press.

Under the heading " General," interesting particulars are given regarding the principal minerals, their uses and value for different purposes. The statement on page 7, regarding the mineral utilized in the manufacture of iron and steel is hardly correct, for a large percentage of 50% manganese ore is smelted in the blast-furnaces, as indicated on page 27, for the production of a pig iron containing 1 to 2% of manganese, which enables the basic process to be more easily worked.

It is noteworthy that the present prices of manganese ore and alloys are within reasonable distance of those of the pre-war period, this being due to the trade depression, and the great reduction in the cost of ocean transport. Further reduction in costs will, no doubt, be obtained as a result of lower railway rates, and the more general application of mechanical plant to the getting of the mineral, particularly in India.

During the war ferro-manganese was made in many countries not hitherto producers, and on a larger scale than heretofore in the United States, so it is probable that this will influence prejudicially the British production of ferro alloys by the imposition of protective duties.

No mention is made of the use of manganese ore for the production of carbon-free metallic manganese, made by the thermit process, which is becoming of increasing importance for nickel, copper, and silver alloys.

Under the title " World's Production," some interesting information is given, but the estimates regarding costs of production of Indian, Brazilian, and Caucasian ores, taken from Dr. Fermor's book published in 1909, have now only historical value. The three Indian deposits, of which estimated reserves are given, did not contribute appreciably in recent years to the output, and other properties of much greater importance exist in the Central Provinces of that country. So little development work has, however, been carried out on any of them that any estimates must be only approximations, although those who have seen the ore-bodies are convinced that the potential reserves are very large.

With regard to the Brazilian deposits, the principal one, Morro da Mina, has been recently acquired by the United States Steel Corporation, and as that concern requires in periods of industrial activity upwards of 500,000 tons per annum of manganese ore for its own consumption, it is probable that amount will be obtained from the deposit in the future.

The present capacity of the world's steel-works is about 100 million tons per annum, which, together with other demands for manganese, will require in times of good trade nearly 3 million tons of ore. This can easily be supplied by known deposits, if transport arrangements are available. At present steel is only being produced at the rate of about 35 million tons per annum, so

that the absence from the market of Caucasian ore is not seriously felt. With the return, however, of favourable trade, there may be a scarcity of rail and ocean transport for Indian and Brazilian manganese ore, unless political conditions in the Caucasus become more settled.

The details regarding the Sinai deposits indicate that although occurring at the base of the Carboniferous Limestone series the mineral may be classed as a manganiferous iron ore containing about 40% manganese and 15% iron, similar to that of the lateritoid deposits of India, Brazil, and elsewhere. The West African deposits at present known are important, and it is probable that others will be discovered in the district as the forest coast belt is cleared. The South African and Canadian deposits are unlikely to provide mineral for export, but are probably of sufficient importance for local requirements; while the Australian deposits appear to be more extensive, although in many cases of the lateritoid type, and their distance from the coast and Europe precludes export, unless rail and ocean transport can be obtained at low rates. Dr. Fermor's classic work has been drawn upon for particulars of the Indian deposits and analyses of the ores.

Of the foreign sources of manganese ore, Georgia, South Russia, and Brazil are the most important. The Russian deposits are especially valuable by reason of their comparative proximity to steel producing countries and low percentage of iron contents which neutralizes the disadvantages of its finely divided condition consequent on its pisolitic and earthy character which is undesirable for the blast-furnace. Owing to the chaotic political position in Georgia it is doubtful when the mines of Tchiatouri will be in regular operation again, although cargoes from stock have reached Western Europe from the South Russian and Caucasian deposits. The deposits of high-grade ore of the Central American republics, Cuba, and United States, do not appear to be very extensive, as no great development of them took place during the war period when the incentive of high prices and national stress should have enabled this to be done. Of the Brazilian deposits in Minas Geraes only that of Morro da Mina has extensive reserves, and is capable of a large output, although several other properties can produce when prices are satisfactory.

H. K. SCOTT.

NEWS LETTERS

MELBOURNE

June 30.

GOLD STEALING IN WEST AUSTRALIA.—A deputation, which included representatives from the Primary Producers' Association, the Chamber of Mines, and the Mining Association, waited on the West Australian Minister for Mines, Mr. Scaddan, early in June for the purpose of urging the necessity of steps being taken to cope with the illicit traffic in gold. The deputation was introduced by Mr. T. H. Harrison, M.L.A., and the principal speaker was Mr. Richard Hamilton, president of the Kalgoorlie Chamber of Mines, who presented a Bill which had been drafted, not with a wish to usurp the functions of the Minister's department, but to save the Minister a lot of time and trouble. He thought the public, and perhaps Parliament, did not appreciate the extent of the evil of gold stealing. If as much value had been stolen in wheat, steps would have been taken to stop the practice. The price of six bags of wheat could be stowed away in a man's mouth in the form of gold without any inconvenience to the man; hence the difficulty of detecting the thefts; for years and years the value of 100,000 bags of wheat had been stolen from mining companies, and they had tried in vain to get prohibitive legislation passed. The Minister, in reply, concurred as to the neglect of successive Cabinets to deal with the matter. The matter was not new, either to him or to his department. He did not know how far the deputation's draft Bill would meet the case, but he would have a Bill embodying the idea prepared, and would consult the Chamber of Mines respecting it. He could not promise that it would be put before Parliament this session, but it would be submitted to the Cabinet, and it would have a good chance of being dealt with this session.

QUEENSLAND GOLD MINING.—The official figures for the month of May, 1921, indicate that the production of gold in Queensland is at a very low ebb, probably the lowest since gold mining has been a recognized industry in Queensland. The chief cause of the falling off was the closing down of Mount Morgan, no gold being won there for the month, as against 6,346 oz. for May in the previous year. Industrial troubles among the workers account in a fair measure for the lessening of the yield,

and scratchers and fossickers are not so numerous as in the years gone by, when they were lured to fields of possible fortune. Last month's output was 2,077 oz., against 8,432 oz. for May, 1920. Charters Towers dropped by 299 oz. to 776 oz.; Gympie increased from 237 to 722 oz.; Chillagoe from 173 oz. to 267 oz.; Etheridge and Oaks fell from 175 oz. to 147 oz.; Croydon, 166 oz. to 74 oz.; Ravenswood produced 72 oz. in both periods. The total yield for the five months to May 31, 1921, was 24,986 oz., being a decrease of 11,701 oz. against the five months of the same period in 1920. The dividends for the five months this year amounted to £4,500, against £49,663 for the same period last year.

MOUNT CUTHBERT COPPER.—During the half year ended February 28 only 63 days' actual work was done at these mines north of Cloncurry, distributed over October, November, and December, and on December 18 the mines and smelter were closed down. As costs and the price of copper have not since adjusted themselves to give a working profit, the mines and smelter remain closed. The amount of blister copper produced during the half-year was just over 693 tons. Of 12,468 tons of ore smelted about half (6,285) came from the Kalkadoon mine, the Mount Cuthbert mine furnishing 3,166 tons, the Orphan 2,415 tons, the Mighty Atom 510 tons, the Surprise 79 tons, and the Little Wonder 13 tons. Since smelting was commenced the total of ore treated has been 123,093 tons, from which 6,768 tons of blister copper was produced. Before the company's own smelter was put up 13,099 tons was smelted at Mount Elliott, which yielded 1,110 tons of blister, making the total tonnage smelted 136,192, for a production of 7,878 tons of blister copper. No fresh estimate has been made of the ore reserves, owing to the limited amount of extraction, and these still stand at 193,500 tons containing 13,245 tons of copper. These figures include 80,000 tons in the Kalkadoon mine, averaging 5% of copper, and there is, in addition, 35,000 tons of limestone flux in the Kalkadoon east lode, averaging 2% of copper. Only 509 ft. of actual development work was done during the half year, but the results are regarded as satisfactory. Chief interest lies in the developments at the Orphan mine, where, at the 100 ft. level, the new ore-body was proved for a length of 231 ft., while the south end was still undeveloped, and the average width was about 20 ft. On the west lode the length of the ore exposed was 255 ft., and the lode was still strong in the north end. The ore in the north drive is regarded as payable. At a depth of 175 ft. the south level was 325 ft. in fair ore, and the face was in ore of high grade.

PERTH, W.A.

August 1.

SUGGESTIONS FOR REFORM.—"The early history of California, New Zealand, Victoria, and West Australia itself have strikingly illustrated the potency of discoveries of gold in stimulating the flow of population and capital into a country. The gold-mining industry has been the main factor in the progress of this State, and the Government should be urged to take immediate steps in the direction of bringing about a revival of that industry." This is the preamble of a notice asking mining men in West Australia to meet and formulate a series of recommendations to the Primary Producers' Association. For some years representatives of goldfields constituencies have devoted their energies to securing benefits for the workers, without giving any consideration to the rights of the owners. However, the general depression in mining has wakened up the primary producers to the fact that something must be done, if the mining industry is to survive. The Chamber of Mines in Kalgoorlie and the Mining Association in Perth have been co-operating in this, and already several suggestions have been made which it is hoped will be introduced to Parliament in the Session just opened. I have in a previous letter dealt with the evidence given by various mining men before the Federal Royal Commission on Taxation. It is expected that an amelioration of some of the anomalies will be secured, such as the taxing of prospectors when they make a find and on the taxation on the transfer of gold-mining leases, both of which are grossly inequitable.

GOLD STEALING.—A gold buyers' bill has been prepared, which will make it very difficult for the receiver of stolen gold to dispose of it. At the present time if a man has a mine, in which rich patches of ore occur, he can augment these by adding stolen gold, without much fear of detection. Under the new bill, if such a mine were suspect, the Warden could order it to be sampled and secure evidence which would enable the police to put the onus of proof

of production on the owner. Recently one such man was caught bringing to the mine 1,000 oz. of amalgam, after midnight. He was arrested, convicted, and sent to gaol for eight months and the gold forfeited. The new bill, it is considered, will go a long way to stopping the gold-stealing evil, in that it will make the receiver's risks too hazardous to be worth taking.

LABOUR QUESTIONS.—The Arbitration Court, which was heralded as the panacea for all troubles by the workers, has resulted in a professional class of advocates whose aim seems to be to keep employer and employee apart. It is now suggested by the committee who waited on the Premier yesterday that as soon as any industrial trouble arises a conference of owners and workers shall be held, under a chairman to be chosen. Each side can state its case, and in this round-table conference it is felt that a better understanding will be come to, than if the case were to be fought on the present lines. It is only the questions which cannot be mutually settled that will be heard by a Supreme Court judge. It is suggested that he be appointed for life, and thus ensure continuity in arbitration work.

The writer has during the past five years been in a position to compare the effects of class warfare on the one hand and co operative working on the other. In the first the costs are high, and neither the employer nor employee is satisfied. In the latter, where everyone works together to make a success of the scheme, it is progressive and financially sound. The latter are men who learnt the value of team work in Gallipoli, Egypt, France, and Belgium, and although some of these men are crippled they are succeeding where other industries are being damaged through want of understanding between the owner and worker. Col. Blackett, at the annual dinner of the Institution, sounded a note that will echo in the hearts of mining engineers the world over, when he spoke of his love for the Durham coal miner. The miner individually, whether he be a coal miner or a gold miner, is a most lovable man ; one has only to see the response to an appeal for help, either in money or in service, when his purse and his life, if necessary, are willingly proffered. It is the professional agitator who is too lazy to work that causes all the trouble, because his living depends upon keeping the owners and workers apart. There are signs that the latter are beginning to realize that they are being led to destruction by the Bolshevistic element which secured control of the trades unions while the loyalist workers went to the war. The soldiers, when they returned, wanted peace, but find they must now fight the enemies in their midst (who stayed at home), if the industries of our fair land are to be saved.

SECURITY OF TENURE.—The subject of security of tenure of mining leases has also been given attention. It is suggested that the expenditure on development work on a lease shall be cumulative in the matter of exemption. That is, assuming £4,000 spent entitles a leaseholder to one year exemption, £20,000 should entitle him to five years, and mines on which a considerable amount of money has been spent may not be payable under existing conditions ; but with the exception of one year exemption, even although £100,000 may have been spent, without any reward, the owner is at the mercy of the Warden. If he fails to protect his lease for one day it may be jumped by any man of straw who comes along. Whereas, if the owner who has spent his thousands on the lease knew that he would be sure of being protected, he would be much more likely to find more money on the lease if conditions improved than the jumper would. There is no equity at all for the leaseholder under the present Act ; and although Ministers have hitherto been unable to see it in this light, perhaps some future Minister may be convinced by the pressing argument of loss of capital to the State which is manifest. A number of suggestions have been made, whereby the leaseholder would have rights more in accord with those granted to holders of other property.

TRIBUTING.—The result of the hasty legislation introduced last year by the Minister of Mines rather appropriately referred to by one manager as the " Tributers Extinction Bill," has been that the companies will not renew existing tributes nor grant new ones. A Royal Commission, with the Warden of Kalgoorlie as chairman, a member of the Chamber of Mines, and one from the Miners' Union, has been appointed to inquire into this question, and is now taking evidence. It is hoped that some workable agreement can be come to, whereby instead of a term of three years, which can now be demanded as the length of the tribute, irrespective of how impossible it may be for the owner, it is proposed that the

tribute agreement shall be subject to six months' notice of termination, which is much fairer. The terms will no doubt be made more equitable so that after the tributer has made wages the owner shall receive a fair share as royalty.

HAMPTON PLAINS.—Ives Reward, which is situated on the south side of Lake Lefroy, on the continuation of the line extending from Boulder through Celebration and White Hope, is being reported on by the manager of the last-named company. It is a big lode, on which glowing reports have been made by the prospector and manager. The report by this well-known mining engineer, N. E. Giblin, will therefore be looked for with keen interest, as it may mean another big mine. If so it would be an incentive to genuine work on a field which was born in a boom, and its development frustrated by companies with big share capitalization, but little working capital.

The prospector of the new Monger field, McCahon, who has done some good work on his lease, has cut the Monger Proprietary lode at a depth of 160 ft., and it is said to carry high values. A battery has been erected on the field, and no doubt a number of rich crushings will be secured from pipes of ore, but the mines are not suitable for companies, being more suitable to parties of working miners.

The reports from the Celebration recently have been anything but reassuring. The lode in the 300 ft. level, occurring as it does in contact with the jasper and porphyry, is patchy, and dispels any doubt as to its similarity in origin to the lodes at Boulder. It was questionable when this lode was found whether it was derived from the quartz-dolerite on the one wall or the porphyry on the other. Owing to the oxidation and alteration of the lode material it was impossible at the 100 ft. level to say from which of these wall-rocks the gold came. The majority of mining engineers and geologists who inspected the mine and the field were of opinion that the lode was identical with those on the Golden Mile. That opinion has proved to be wrong. At the same time there is no reason for the statements issued in a recent editorial in the *Times* that the reports were made by "two a penny mining men." It was the very fact that several leading mining engineers in West Australia were the vendors of the Celebration when it averaged 50s. over 20 ft. in width that caused the boom. It was the hundreds of companies that were floated on the strength of this property, on leases without any apparent ore-bodies, and not accompanied by a report by an accredited mining engineer, that was the greatest mistake. This applies also to the mines on the Mount Monger field, which was condemned by the writer in these columns right from the start.

FLOTATION AND REPORTS.—During the war companies could not be floated without the sanction of the Federal Minister dealing with this, and he insisted on a report being made by some reliable man as to the justification of that company and its prospects. Had this wise war-time measure been retained, only those leases on which a lode carrying reasonable prospects of gold would have been allowed to be floated, and the numerous wild-cat companies would never have come into existence. Whether the State Government will take this lesson remains to be seen; probably they will, as in the past, say it is not their business, but this it surely is if they wish West Australian mining to regain the confidence of the investing public.

OIL.—There was some wild excitement in Perth recently when a local paper published news that an oil flow had been struck at Bremer Bay, near Ravensthorp, and that the owners were claiming the reward of £5,000 offered by the Government for the discovery of a payable oilfield. Inquiries elicited the fact that the rumour arose because a boring plant had arrived to test several points where good surface indications were found. Considerable Tertiary and Post-Tertiary beds exist at the back of Bremer Bay, and it is here that the prospecting work is being carried on.

The Assistant State Mining Engineer (Mr. Torrington Blatchford) is still in the Kimberley district investigating certain oil indications there, which had been reported to the Mines Department. He has sent down several samples for preliminary examination, as a guide to his Geological Survey.

NORTHERN WEST AUSTRALIA. — The Government realizes the possibility of the great Nor' West of this State, and have appointed Major Drake-Brockman, an engineer, as a First Commissioner to reside there and collect information, with Mr. Blatchford as his mining adviser. Those men who have lived in that tropical portion of West Australia are all enthusiastic as to its mineral possibilities.

TORONTO

August 10.

Porcupine.—The gold-mining industry has entered upon a period of prosperity and expansion. Labour is plentiful and efficient, and operating costs are being steadily reduced by the adoption of modern methods and devices. The gold production of Ontario during the present year to date is estimated at about $7,600,000, of which approximately $6,700,000 was the output of the Porcupine camp. The Dome Mines during the three months ended June 30 realized net profits of $235,697, being at the rate of 20% on the issued capital. The grade of ore taken from the lower levels is much higher than that formerly treated, rendering possible larger returns to the shareholders. It is officially stated that the present dividend rate of 10% per year will be continued, and that any further distribution of profits will be in the form of a return of capital. The McIntyre has cut a vein 30 ft. wide stated to carry $20 to the ton on the 1,375 ft. level, which is being opened up. A station has been cut on the 1,625 ft. level, and the sinking of the shaft to a depth of 2,000 ft. is being continued. The management has decided to proceed at once with the construction of an addition to the mill, increasing its capacity from 500 tons per day to 1,000 tons. The production of the Hollinger Consolidated is about $800,000 per month, and dividends of 1% every four weeks continue regularly, the aggregate disbursements for the year amounting so far to $1,968,000. At the Porcupine Paymaster, situated about 2 miles south-west of the Dome, development is meeting with satisfactory results. The vein is 20 ft. wide in places and is paralleled by other good veins. The shaft will be put down to the 400 ft. level. Lateral work is under way at the 300 ft. level of the Beaumont, formerly the North Davidson, to cross-cut promising veins indicated by diamond-drilling. Development is being undertaken on the Gold Island property on Night Hawk Lake with A. R. Globe, formerly assistant manager of the Hollinger, as manager. The Allied Porcupine Mines has unwatered the Three Nations mine, which it recently took over, and will resume underground work. The March Gold is arranging to instal a mining plant, surface work having been attended with encouraging results.

Kirkland Lake.—The Lake Shore during June established a new high record, with a production of $52,539 from the treatment of 1,656 tons of ore, being an average recovery of $31·73 per ton. Present development work is being carried on at the 400 ft. and 600 ft. levels with excellent results. Dividends of 2% have been declared payable August 10 and November 10. The Ontario Kirkland is making good progress with the construction of its mill, which it is hoped will be ready for operation this fall. A new shaft is being made near the mill site by rising from the 300 ft. level to connect with a shaft started from the surface. The grade of ore latterly taken out by the Teck-Hughes is running high. A new grinding and classifying unit is to be added to the mill, which will increase its capacity from 100 to 160 tons daily. The Sylvanite mine is being taken over by the Kirkland Lake Proprietary (1919) conjointly with a group of American financiers. The unissued 80,000 shares of the present Canadian Sylvanite Co. will be purchased for $400,000, and the company reorganized with a total capital of $3,000,000 in shares of $1 each. Existing shareholders will receive $2,000,000 in the ratio of five shares for one, and the remaining 1,000,000 shares will be held in reserve, the Kirkland Lake Proprietary and the American group to have the option for two years of acquiring 500,000 shares each. The Wright-Hargreaves during June produced over $51,000, though the mill lost 25% of possible running time owing to power difficulties. The mill is now handling 150 tons of ore per day, mainly development ore. Stopes have been opened up in several parts of the mine. At the King Kirkland a new vein 7 to 10 ft. wide and heavily mineralized has been discovered by surface trenching. The drift at the 300 ft. level of the Bidgood has been in ore for upwards of 100 ft. Surface work at the Wood-Kirkland has uncovered several veins, one of which especially appears of considerable importance. Lateral work will be undertaken to cut these veins at the 100 ft. level. The Queen Lebel, a new company, capitalized at $2,000,000, has been formed to operate a group of claims on the south-east side of Gull Lake. An 8 ft. vein has been opened up at the surface.

Cobalt.—The silver-mining industry, though still depressed, is showing more activity, and the outlook is improving, owing to the strengthening in the price of silver, and more favourable economic conditions. It is still handicapped, however, by high freight rates, and a wage rate, which, notwithstanding the recent reduction, is

higher than many of the mines can pay with a margin of profit. The Nipissing during June mined ore of an estimated net value of $162,824, and shipped bullion from Nipissing and custom ores of an estimated net value of $208,526. The production of cobalt has become an increasing factor, the output of this metal in June (included in the above) being $25,560. The mill of the Mining Corporation of Canada is treating about 300 tons of ore daily, containing an average of approximately 20 oz. of silver per ton, indicating an output of about 2,190,000 oz. annually. The La Rose Consolidated is extending its operations, and has unwatered and resumed the development of the Violet property, adjacent to the O'Brien. The Hudson Bay is preparing to resume milling operations for the treatment of broken ore to the amount of 6,000 tons. When this is done the directors will decide whether to undertake further development or close down the mine. The Bailey custom mill during July operated at capacity, treating 4,043 tons of ore and realizing gross earnings of $12,129. The shaft on the Waldman property of the Oxford Cobalt is down 50 ft., placing some high-grade and a substantial quantity of milling ore in sight.

LIGHTNING RIVER.—A rich find of gold has been made on the claims of the Lightning River Gold Mines, Ltd., in Harker Township, 8 miles south of Lake Abitibi. The vein is 54 in. wide, with free gold across the whole width. The richness of the ore has caused much excitement, and a rush of prospectors to the district has commenced.

LARDER LAKE.—The large three-compartment shaft of the Canadian Associated Goldfields has been put down to the 350 ft. level, and cross-cutting towards large ore-bodies indicated by drilling has begun on the 175 ft. and 320 ft. levels. The company has been able to effect great economies in transport by the use of a caterpillar tractor, capable of carrying a load of 11 tons. The Crown Reserve of Cobalt is exploring its Larder Lake claims, and has uncovered an important vein system.

VANCOUVER, B.C.

August 20.

SILVER-LEAD.—With the exception of the activities of the two big smelting companies, both of which are being operated at close to capacity, mining in the Province remains quiet, although there has been considerable improvement during the past month. The Granby Consolidated Mining Smelting & Power Company is turning out about two and a half million pounds of copper monthly, and, judging from the fact that the company's engineers have examined several silver-lead properties recently, it would appear that the management is contemplating the addition of a lead smelting and refining department to its plant. In fact, there would seem to be an opening for such a plant on the northern coast of British Columbia. Great activity is being exhibited this summer at the Mayo camp in Yukon, and at the present time ores from there are being shipped to the Selby smelter, on San Francisco bay, a very expensive haul that is made possible only by the high-grade nature of the ore. More than two thousand claims have been staked in the Keno Hill district, near Mayo, and among the parties that are developing ground there are the Yukon Gold Company, and F. W. Bradley, of the Bunker Hill and Sullivan. The ore that has been shipped is a high-grade silver-lead ore, running about 200 oz. in silver and 60 to 70% of lead. Of course, there is a quantity of ore of a much lower grade, and the Yukon Gold Company is contemplating the erection of a concentrating plant next year. This camp, together with the Salmon River and Alice Arms camps and the recent discovery of silver-lead ore in the Atlin mining division, would seem to warrant the erection of a lead smelter on the coast in the northern part of the Province, and no one is better fitted to undertake the enterprise than the Granby company, which already has an excellent staff of trained metallurgists at Anyox.

PREMIER GOLD.—The Premier Gold Mining Company has put the first 100 ton unit of its combined concentrating and cyanide plant into operation, and it is said to be giving complete satisfaction. A quantity of concentrate has been sacked, ready for shipment, but at the present time the condition of the road between the mine and tide-water prevents it being moved. The construction of the aerial tramway, which will be $11\frac{1}{2}$ miles long, is being pushed, and ore-bunkers are being built at Stewart, the shipping point. A rather wet summer, and consequent soft condition of the roads, has delayed the work appreciably. The Fish Creek Mining Co., which is operating a mine on the Alaskan side of the international boundary, has sent a trial shipment to the

Selby smelter, and has some 20 tons of ore sacked ready for shipment over the winter snows. The ore from this mine is said to be similar to the Premier ore, containing gold and silver, and having an assay-value of between $500 and $600. Like the Premier, too, the property is rather inaccessible, high up on a mountain, and for the present will have to depend on winter snow for the transport of its ore. The Alaskan Government, however, has made arrangements for the building of a waggon-road to the mine. Probably more than 100 tons of ore will be taken from the property during the coming winter.

Dolly Varden.—The Dolly Varden mine, which produced some 850,000 oz. of silver last year, is in litigation once again. It will be remembered that, in the closing hours of the 1920 session of the Provincial Legislature, an Act was passed taking the mine out of courts and vesting its ownership in the Taylor Mining Company. Among the liabilities that the Taylor company had to assume was a mortgage on the property for $150,000, given by the previous owners, the Dolly Varden Mines, Ltd., to George Wingfield, of Reno, Nevada, who was president of the company. This mortgage fell due on July 31, and Mr. Wingfield is suing the Taylor Mining Co., the Taylor Engineering Co., and Charles M. Rolston, of Vancouver, for the amount together with accrued interest, which brings it up to $182,322. The plaintiff asks for an accounting, for foreclosure, for possession, and for the appointment of a receiver. The president of the Taylor Mining Co. paid a visit to England last winter, it is stated for the purpose of raising funds for the erection of a concentrating and cyanide plant to obtain more economical production. No announcement was made on his return, so, presumably, his mission, if such it was, failed. Neither the railway nor the mine was opened this spring, but a few weeks ago the railway was put into operation for the purpose of shipping some 3,000 tons of ore that was mined, but not shipped, last year. A little development work was started, and this has resulted in the discovery of another ore-body, some 20 ft. above the old workings. The extent of the new discovery has not yet been determined, as it is covered by a rock slide, and a considerable amount of work will be necessary to discover its extent. A sampling across 4 ft., however, gave an assay of 57 oz. of silver per ton, while picked samples ran up to 267 oz.

The Consolidated Mining & Smelting Company is maintaining the production of lead and zinc from its Sullivan mine, at Kimberley, and considerably increasing the production from its Rossland mines, which contain essentially gold ores, with just about sufficient copper for the collection of the precious metals. The copper output from the smelter will be small, probably less than four million pounds, but the gold, silver, lead, and zinc outputs should be considerably in excess of last year, as the total tonnage treated at the smelter up to the middle of August was 260,924 tons, compared with 383,112 tons for the whole of last year. With the exception of about 5,000 tons, all the ore has come from the company's own mines. The Consolidated company has two surveying parties exploring what is known as the Esquimalt & Nanaimo land grant, on Vancouver Island. This belt of land was granted to the Canadian Pacific Railway by the Dominion Government in consideration for the construction of the railway, the Consolidated being to all intents and purposes a subsidiary of the C.P.R. The monopoly of this belt of land has deterred prospecting on the Island, and last year the Provincial Minister of Mines took the matter up with the C.P.R., with the result of the present survey, which will determine exactly what ground the company desires to retain. The remainder will be turned over to the Provincial Government, and will be opened for location.

Other Mines.—The new concentrating plants at the Le Roi No. 2 at Rossland, and the Ottawa mine, at Slocan, have been put into operation, and are said to be working satisfactorily. Several properties in the Slocan have either changed hands or been leased or optioned, and a good deal of development and explorative work is being done, but little actual production.

Limonite. — Part A of the Summary Report of the Canadian Geological Survey, which has been issued recently, is of particular interest to British Columbians, in that it contains a report of the limonite deposits in the Taseko valley, in the Lillooet division. Considerable excitement was caused in 1919 by the announcement of the discovery of an immense deposit of limonite. W. M. Brewer, one of the district engineers connected with the Provincial Department of Mines, was sent to make a reconnaissance of the deposit. From such a reconnaissance he was rash enough to make an estimate that

the deposit contained upwards of seven million tons of actual ore and fifty million tons of possible ore. To confirm this the Provincial Department of Mines sent F. J. Crossland, an independent mining engineer, to make a thorough examination, while the Geological Survey sent J. D. MacKenzie for the same purpose. Both engineers spent the greater part of last summer in the field, and their estimates, which agree closely, place the actual ore at little more than 650,000 tons. This ore is distributed in isolated patches over an area of some 50 square miles, and, owing to the inaccessibility of the situation, is of no commercial value.

PERSONAL

W. H. GOODCHILD has left for Kirkland Lake, Ontario.

B. B. GOTTSBERGER has been elected secretary of the Mining and Metallurgical Society of America. He is a Columbia man, and one of his first appointments was on the staff of the El Oro company. In 1900 he became assistant to J. Parke Channing at the Tennessee Copper Co's. properties, and became manager in 1906. In 1909 he was transferred by the same interests to the Miami, where he was manager for ten years.

A. J. HALE has been appointed professor of applied chemistry in the Finsbury Technical College.

DR. ARTHUR HOLMES has been on a brief visit to London, and has returned to Burma, where he will take up the duties of manager of the Yomah Oil Co. (1920), Ltd.

C. C. LEACH has been elected president of the North of England Institute of Mining and Mechanical Engineers for the coming year.

OWEN LETCHER, editor of the *South African Mining and Engineering Journal*, has gone to India on a three months' visit.

P. B. McDONALD, of New York, has been touring Germany and France.

W. H. MARDALL is resigning the position of secretary to the Johannesburg Consolidated Investment Co., Ltd.

LAURENCE PITBLADO has left for Chile.

RICHARD QUANCE has left for West Africa.

C. A. RICHARDSON is here from Cobalt.

A. T. SNELLING has gone to Mongu, Nigeria.

G. GORDON THOMAS is expected next month from Nigeria.

F. H. TONKING has gone to West Africa.

DAVID WILKINSON is here from Johannesburg.

A. STANLEY WILLIAMS has left for Nigeria.

J. NORMAN WYNNE has left for the Pahang Consolidated Company's mines in the Federated Malay States.

H. H. YUILL, of Bainbridge, Seymour & Co., Ltd., is visiting the Shetland Isles.

HERMANN LANDAU, a stockbroker well known in former years in connexion with West Australian mining, died on August 23.

SIR SAMUEL C. DAVIDSON, head of the Sirocco Engineering Works, Belfast, died on August 18. He started life as a tea planter in northern India, and while engaged in that industry came to the conclusion that mechanical methods should be introduced. His most important invention was the Sirocco fan, designed for the purpose of drying the tea leaf. In 1881 he started the manufacture of this fan and other specialties at Belfast. As is well known, the Sirocco fan has nowadays many other applications than tea drying, and it is as widely used for mine ventilation as for the purpose for which it was originally designed.

THE LATE WILLIAM CROSLEY. As briefly announced last month, William Crosley died at the end of July. He had returned only recently from Nigeria, and was completing his arrangements to go out to the Gold Coast when an attack of heart failure carried him off suddenly in London. He came of a family of civil engineers, his father having been associated with the construction of some of the earliest railways in England. For the greater part of his career he was engaged in gold mining, but in his earlier years he gained a practical knowledge of engineering in colliery work, his first responsible post being as chief surveyor to the Pemberton Collieries, near Wigan. In 1887 he transferred his activities to gold mining, going out to take charge of the Sucré gold mines in Colombia, South America, which post he held for ten years. He then went to Rhodesia as manager for the Rhodesian Gold Trust, afterwards acting as consulting engineer to the Charterland Gold Fields and the Mashonaland Agency. From 1904 to 1909 he was on the Gold Coast in charge of the Prestea Block A. For the following three years he was engaged in exploration work in Mexico, travelling over many parts of the country to report on mines and properties. Circumstances then recalled him to Prestea, where he spent three strenuous years developing and reorganizing the mine and the native village. During the war he was engaged in Burma developing wolfram mines. The last year of his life he was in charge of a group of tin mines in Nigeria for Tarbutt & Janson, from which post, as above stated, he had only recently returned at the time of his death. In the intervals between these long engagements he reported on various mines in the South of France, North of Spain, and Portugal. Besides being a mining engineer of high repute, it is interesting to record that Mr. Crosley was an artist of considerable ability. His sketch-book was invariably packed with his luggage, and he contributed several articles and reports for scientific and official purposes, illustrated with beautifully executed sketches. He was a member of the Pastel Society, and his work has been exhibited at their shows in London for several years past. He had completed a handbook on surveying for the use of settlers only on the evening previous to his decease.

TRADE PARAGRAPHS

F. A. WILKINSON & PARTNERS, LTD., of Hatfield, are making small wind-power electric generating plant.

T. L. REED COOPER, of 11, Tothill Street, Westminster, has issued a new catalogue of his immersible electric pumps.

EDGAR ALLEN & CO.'s works at Sheffield are described and illustrated in *Engineering* for August 19 and 26 and September 2.

The HARDINGE COMPANY, of New York (London office, 11-13, Southampton Row), have issued No. 6 pamphlet on Grinding Data, dealing with eight-foot ball-mills.

The METROPOLITAN-VICKERS ELECTRICAL CO., LTD., of Manchester, and 4, Central Buildings, Westminster, send us Circular 1790/1, dealing with motor equipments for main rolling-mill drives.

F. W. BRACKETT & CO., LTD., of Colchester, have issued a bulky catalogue dealing with air-compressors, dry vacuum pumps, wet vacuum pumps, plunger pumps, centrifugal pumps, and steam engines.

The INGERSOLL-RAND CO., LTD., has been registered at Somerset House as a private limited company to carry on the English business of this well-known American corporation. W. M. Treglown is chairman, and D. M. Armstead is manging director.

HENRY BATH & SON, LTD., metal and mineral brokers, of London, Liverpool, and Swansea, send us a copy of conversion tables containing factors for converting cents per pound into pounds per ton, according to the variations in the dollar exchange.

NOBEL INDUSTRIES, LTD., of Nobel House, Buckingham Gate, London, S.W. 1, send us three new pamphlets: Blasting in Collieries and Hints on Electric Shot-Firing; Blasting Explosives and Accessories; and Ground-Clearing with the aid of Explosives.

The BUCYRUS COMPANY, whose headquarters are at Wisconsin, U.S.A., and who have hitherto been represented on this side by Messrs. G. F. West & Co., announce that they have now opened their own London office at 19, Iddesleigh House, Caxton Street, Westminster, S.W. 1, to which address all communications should in future be forwarded.

The METROPOLITAN-VICKERS ELECTRICAL CO., LTD., of Manchester, and 4, Central Buildings, Westminster, send us their circulars 1,266/1, 1,266/2, and 1,254/1, dealing respectively with oil circuit breakers type G2, oil circuit breakers type G11, and the breaking capacity of switches and circuit breakers.

HEAD, WRIGHTSON & CO., LTD., of Stockton-on-Tees, and 5, Victoria Street, Westminster, are re-issuing their catalogue of mining machinery in sectionalized form. The sections already received deal respectively with jaw-crushers, crushing rolls, grinding pans, Nissen stamps, the Colorado impact screen, the Notanos tube-mill, the Colorado rod-mill, the Colorado convertible-discharge ball-mill, the Akins classifier, the Lowden patent dryer, the Notanos patent rotary dryer, and the Skinner patent roasting furnace.

G. A. HARVEY & CO. (LONDON), LTD., of Woolwich Road, and Suffolk House, Laurence Pountney Hill, London, are exhibiting their specialties at the International Shipping, Engineering, and Machinery Exhibition at Olympia: Perforated metals for all industries, with over 3,000 designs; colliery and quarry screens; perforated conical slotted copper for sugar centrifugals; perforated brass radiator and pipe guards; ventilating panels and piping; storage tanks; steel lockers and cupboards; steel storage bins; heavy mild steel hoppers and cyclones; transformer tanks; sheet steel and plate work of all descriptions.

JOHN & EDWIN WRIGHT, LTD., of the Universe Rope Works, Birmingham (London office, Salisbury House, E.C. 2), have a representative show at the International Shipping, Engineering, and Machinery Exhibition, Olympia. The exhibit includes highest quality steel-wire ropes, for the engineering, marine, mining, oil well, and logging industries, including locked coil, flattened strand, non-rotating, and other special constructions of wire ropes, for winding, sinking, haulage, bridge suspensions, aerial ropeways, cranes, elevators, etc.; also running ropes, cargo hauls, standing rigging, etc.; high-grade plough steel steam ploughing ropes and steel-wire rope slings for heavy lifting purposes; specially flexible high-grade tinned plough steel cables and strands for aircraft, etc.; high-grade cotton driving ropes, hemp, manilla, etc.; ropes and cordage for shipping, crane and capstan ropes, manilla and hemp ropes for shipping and fishing industries.

METAL MARKETS

COPPER.—The course of values on the standard market in London during August was fairly steady until about the middle of the month, when an easier tendency was noticeable, and although the last few days of August saw a slight recovery, values showed a loss on balance. The easiness was due to a wave of pessimism which appeared in the market, and it seemed as if certain holders were tiring of their burden. The outlook was—as is still the case—very obscure, and with consumers' demand continuing restricted, the situation presented very little to encourage a bullish view. In the United States there was at one time rather more demand for the metal, but sellers immediately put prices up, according to their usual habit, with the result that the buying movement was scotched, followed by a rapid weakening in values, which was, of course, reflected sympathetically in London. At the moment the best foreign customer of the United States copper producers is Germany, but the recent depreciation of the mark has had a somewhat restraining effect on her purchases. As regards the position in England, manufactured material continues in poor demand, and makers report that the Continent is able to secure a substantial proportion of the available business. It is hoped, however, that the reduction in the price of fuel will assist British manufacturers to compete more advantageously in the near future. The month saw a moderate demand for sheets from India. There has been much talk recently of Germany establishing credits in the United States, and should the scheme succeed it is to be expected that exports of copper to that country might show a certain increase.

Average price of cash standard copper: August, 1921, £68 12s. 8d.; July, 1921, £71 4s. 4d.; August, 1920, £94 1s.; July, 1920, £90 5s. 6d.

TIN.—The standard tin market in London fluctuated within moderate limits during August, but the trend of values was downward until the last few days, when a recovery took place, apparently on speculative buying. In the absence of much genuine consumptive demand, a weak tendency was practically inevitable, and the occasional rallies were due merely to bear covering and other tactics of the professional operators. The general position has thus shown very little change during the month, the large unabsorbed stocks in the East continuing to hang over the market, with an unfavourable effect on sentiment. One reason why the market receives so little support is doubtless the fact that holders find their existing stocks a sufficient burden without adding to them. It is difficult to see any hope of a sustained improve-

Daily London Metal Prices: Official Closing
Copper, Lead, Zinc, and Tin per Long Ton ;

Copper

August	Standard Cash £ s. d. £ s. d.	Standard (3 mos.) £ s. d. £ s. d.	Electrolytic £ s. d. £ s. d.	Wire Bars £ s. d. £ s. d.	Best Selected £ s. d. £ s. d.
9	72 0 0 to 72 2 6	70 7 6 to 70 10 0	74 0 0 to 75 0 0	74 0 0 to 75 0 0	70 0 0 to 72 0 0
10	70 2 6 to 70 5 0	70 10 0 to 70 12 6	75 0 0 to 76 10 0	75 0 0 to 75 10 0	70 0 0 to 72 0 0
11	70 0 0 to 70 2 6	70 5 0 to 70 7 6	75 0 0 to 76 0 0	75 0 0 to 76 0 0	70 0 0 to 72 0 0
12	69 15 0 to 69 17 6	70 0 0 to 70 2 6	74 10 0 to 76 0 0	74 10 0 to 76 0 0	69 15 0 to 71 15 0
15	69 17 6 to 70 0 0	70 5 0 to 70 7 6	74 0 0 to 75 0 0	74 0 0 to 75 0 0	69 15 0 to 71 15 0
16	69 10 0 to 69 12 6	69 17 6 to 70 0 0	73 10 0 to 74 10 0	73 10 0 to 74 10 0	69 10 0 to 71 10 0
17	68 2 6 to 68 5 0	68 12 6 to 68 15 0	72 10 0 to 73 10 0	72 10 0 to 73 10 0	69 10 0 to 71 10 0
18	67 5 0 to 67 7 6	67 15 0 to 67 17 6	71 10 0 to 73 10 0	72 10 0 to 73 10 0	69 10 0 to 71 10 0
19	67 2 6 to 67 5 0	67 12 6 to 67 15 0	71 10 0 to 73 0 0	72 0 0 to 73 0 0	67 5 0 to 69 5 0
22	66 5 0 to 66 7 6	66 15 0 to 66 17 6	71 0 0 to 72 10 0	71 10 0 to 72 10 0	67 5 0 to 69 5 0
23	66 0 0 to 66 2 6	66 15 0 to 66 17 6	70 10 0 to 72 0 0	71 0 0 to 72 0 0	66 0 0 to 68 0 0
24	66 15 0 to 66 17 6	67 5 0 to 67 7 6	70 10 0 to 72 0 0	71 0 0 to 72 0 0	66 0 0 to 68 0 0
25	66 5 0 to 66 7 6	66 17 6 to 67 0 0	70 10 0 to 72 0 0	71 0 0 to 72 0 0	66 0 0 to 68 0 0
26	67 10 0 to 67 12 6	68 2 6 to 68 5 0	70 10 0 to 72 10 0	71 0 0 to 72 10 0	67 10 0 to 69 10 0
29	67 17 6 to 68 0 0	68 10 0 to 68 12 6	70 10 0 to 72 10 0	71 0 0 to 72 10 0	67 10 0 to 69 10 0
30	67 12 6 to 67 15 0	68 5 0 to 68 7 6	71 10 0 to 73 10 0	72 0 0 to 73 10 0	67 15 0 to 69 15 0
31	67 15 0 to 68 0 0	68 12 6 to 68 15 0	71 10 0 to 73 10 0	71 10 0 to 73 10 0	67 15 0 to 69 15 0
Sept.					
1	67 15 0 to 67 17 6	68 12 6 to 68 15 0	71 10 0 to 73 10 0	72 0 0 to 73 10 0	67 15 0 to 69 15 0
2	68 12 6 to 68 15 0	69 10 0 to 69 12 6	71 10 0 to 73 10 0	72 0 0 to 73 10 0	69 0 0 to 71 0 0
5	68 17 6 to 69 0 0	69 15 0 to 69 17 6	73 0 0 to 75 0 0	73 10 0 to 75 0 0	69 0 0 to 71 0 0
6	68 17 6 to 69 2 6	69 17 6 to 70 0 0	73 0 0 to 74 10 0	73 0 0 to 74 10 0	70 0 0 to 72 0 0
7	68 12 6 to 68 15 0	69 12 6 to 69 15 0	73 0 0 to 74 10 0	73 0 0 to 74 10 0	70 0 0 to 72 0 0
8	67 5 0 to 67 7 6	68 5 0 to 68 10 0	72 0 0 to 74 0 0	72 0 0 to 74 0 0	70 0 0 to 72 0 0
9	67 2 6 to 67 7 6	68 2 6 to 68 7 6	72 0 0 to 74 0 0	72 10 0 to 74 0 0	68 5 0 to 70 5 0

ment in values until there is a broadening of consumption, and while the tinplate industry continues depressed this is hardly likely. Continental inquiry has been on the whole disappointing, and demand from the United States, although occasionally stimulated by the falls here, has also been poor. In the Straits sales have been made in fair quantities at about the London parity, and sellers there have evinced quite an eager desire to dispose of metal. Batavia sells occasionally. China, however, has continued to hold aloof. Some hopes are held that the tinplate industry is on the eve of a recovery, owing to the absorption of the war stocks of canned goods and the fact that the relief of the Russian famine will entail the dispatch of vast quantities of tinned meats to the stricken districts.

Average price of cash standard tin: August, 1921, £155 8s. 4d.; July, 1921, £164 13s. 1d.; August, 1920, £274 5s. 10d.; July, 1920, £262 1s. 5d.

Lead.—The London lead market kept remarkably steady during August, and closing values were very little below those at which the month opened. This was due to no small extent to the fact that, unlike most of the other non-ferrous metals, there was quite a fair demand from consumers, which helped to sustain values. This fact is all the more surprising when it is remembered that lead is, relatively, the dearest metal of the four dealt in on the London Metal Exchange. Holders of the metal have not relaxed their firm attitude to any extent, and the spot position has remained tight, aided by irregular shipments and the policy adopted by consumers of buying for prompt delivery only. There is a fairly general opinion that arrivals from Spain are likely to be erratic and restricted for some time to come. On the other hand, reports speak of greater activity at the Mexican smelters, so that supplies from that quarter should be on an increased scale in the near future. It is interesting to notice that the Government has at last disposed of their stocks of lead, estimated at about 10,000 tons. At the beginning of the month there was quite a fair inquiry from the Continent, but later on demand fell away, perhaps owing to American competition there. In the United States the market appears to have a quiet tone, and although the leading producers have made no alteration in their price, lead in bond can be bought at less. News is to hand that the Port Pirie smelter in Australia has resumed operations. The smelter in question was, it will be remembered, recently burnt down, and the reconstructed plant has probably less than half the roasting capacity of the old one, its maximum being about 3,000 tons of concentrates weekly. The actual scale of working will depend almost entirely upon the activities of the Broken Hill mines.

Average price of soft pig lead: August, 1921, £23 5s. 1d.; July, 1921, £23 5s. 10d.; August, 1920, £36 8s. 10d.; July, 1920, £35 9s.

Spelter.—Values in the London spelter market had an easier tendency during the month, despite a slight improvement in the galvanizing trade and a consequent better demand for spelter. The easiness appears to have been due chiefly to the developments in the German situation. The renewed depreciation of the mark led to the natural supposition that exports of spelter from that country might again be feasible on a fair scale. As a matter of fact, a quantity of German spelter has actually been sold here, but there has been no selling pressure from that quarter. Other producing countries have been adopting a rather reserved attitude. Belgium sold a little, and there were offerings of Austrian metal. Norway was a prospective seller at the beginning of the month, but ceased to offer later. The future of the market is largely dependent on whether foreign holders are able to finance their stocks. Consuming demand generally, despite the improvement above referred to, is still none too satisfactory. In America rather a better trade inquiry was reported at the beginning of the month, but this appears to have failed to develop into a serious buying movement, and the position there continues in a deplorable state. Despite the efforts of producers to keep down output, stocks continue to increase, being now more than 90,000 tons.

Prices on the London Metal Exchange.

Silver per Standard Ounce ; Gold per Fine Ounce.

Lead: Soft Foreign	Lead: English	Zinc (Spelter)	Standard Tin: Cash	Standard Tin: 3 mos.	Silver: Cash	Silver: Forward	Gold	
£ s. d. £ s. d.	£ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	d.	d.	s. d.	Aug.
23 15 0 to 23 7 6	25 0 0	25 17 6 to 26 12 6	162 10 0 to 162 15 0	164 10 0 to 164 15 0	36¼	36¼	111 4	9
23 12 6 to 23 5 0	25 0 0	25 17 6 to 26 12 6	159 5 0 to 159 10 0	161 5 0 to 161 10 0	37	36¾	112 7	10
23 10 0 to 23 0 0	24 15 0	25 10 0 to 26 5 0	157 0 0 to 157 5 0	158 10 0 to 158 15 0	37⅛	37⅜	112 5	11
23 10 0 to 23 2 6	24 15 0	25 10 0 to 26 2 6	155 5 0 to 155 10 0	156 5 0 to 156 10 0	37½	37⅛	112 1	12
23 12 6 to 23 5 0	24 15 0	25 10 0 to 26 2 6	155 5 0 to 155 10 0	156 10 0 to 156 15 0	38	37⅝	112 0	15
23 12 6 to 23 5 0	24 15 0	25 2 6 to 25 15 0	154 15 0 to 155 0 0	156 0 0 to 156 5 0	38	37¾	112 4	16
23 12 6 to 23 5 0	24 15 0	25 0 0 to 25 5 0	151 10 0 to 151 15 0	152 10 0 to 152 15 0	38⅛	38⅛	113 1	17
23 12 6 to 23 2 6	24 15 0	24 12 6 to 25 5 0	151 10 0 to 151 15 0	153 0 0 to 153 5 0	38⅜	38	112 6	18
23 7 6 to 22 17 6	24 15 0	24 12 6 to 25 5 0	152 7 6 to 152 10 0	154 0 0 to 154 5 0	38⅝	38¼	112 5	19
23 2 6 to 22 12 6	24 5 0	24 12 6 to 25 5 0	152 10 0 to 152 12 6	154 5 0 to 154 7 6	37¾	37⅝	112 3	22
23 0 0 to 22 10 0	24 5 0	24 10 0 to 25 0 0	152 2 6 to 152 5 0	153 15 0 to 154 0 0	38	37⅞	112 4	23
23 0 0 to 22 7 6	24 5 0	24 7 6 to 25 0 0	150 0 0 to 150 5 0	151 10 0 to 151 15 0	38½	38	111 11	24
23 5 0 to 22 15 0	24 5 0	24 15 0 to 25 2 6	149 0 0 to 149 0 0	150 15 0 to 151 0 0	38¼	38	111 4	25
23 7 6 to 22 15 0	24 5 0	24 15 0 to 25 5 0	152 0 0 to 152 5 0	154 0 0 to 154 5 0	38	37¾	111 6	26
23 7 6 to 22 15 0	24 5 0	24 15 0 to 25 7 6	153 5 0 to 153 10 0	155 5 0 to 155 10 0	38¼	37¾	111 4	29
23 5 0 to 22 15 0	24 5 0	24 17 6 to 25 10 0	156 10 0 to 156 15 0	158 15 0 to 159 0 0	38½	37¾	111 1	30
23 5 0 to 22 15 0	24 5 0	24 15 0 to 25 10 0	157 0 0 to 157 5 0	159 5 0 to 159 10 0	38⅞	37½	110 4	31
								Sept.
23 10 0 to 22 17 6	24 10 0	24 12 6 to 25 10 0	154 10 0 to 154 15 0	156 12 6 to 156 17 6	37¾	37⅜	110 4	1
23 7 6 to 22 15 0	24 10 0	24 7 6 to 25 5 0	156 15 0 to 157 0 0	159 0 0 to 159 5 0	38¼	37¾	109 8	2
23 5 0 to 22 15 0	24 5 0	24 12 6 to 25 10 0	159 5 0 to 159 10 0	161 15 0 to 162 0 0	38⅞	38⅛	110 10	5
23 5 0 to 22 15 0	24 5 0	25 0 0 to 25 15 0	161 5 0 to 161 10 0	163 15 0 to 164 0 0	39⅛	38⅝	110 9	6
23 7 6 to 22 17 6	24 5 0	25 2 6 to 25 17 6	161 17 6 to 162 2 6	164 10 0 to 164 15 0	38⅜	38⅜	110 10	7
23 2 6 to 22 12 6	24 5 0	25 2 6 to 25 15 0	159 0 0 to 159 5 0	161 10 0 to 161 15 0	38¾	38¼	110 1	8
23 7 6 to 22 17 6	24 5 0	25 7 6 to 25 17 6	156 5 0 to 156 10 0	158 15 0 to 159 0 0	38¾	38¾	110 1	9

Average price of spelter : August, 1921, £25 8s. ; July, 1921, £26 12s. ; August, 1920, £41 19s. 6d. ; July, 1920, £42 13s. 3d.

Zinc Dust.—Values have kept very steady. High-grade Australian is priced at £55 per ton, and English and American 92 to 94% about £52 10s.

Antimony.—Prices were unaltered during the month. English regulus ordinary brands, £37 to £40 ; special brands, £38 5s. to £42, and 98% to 99% £29 to £32. Foreign in warehouse is steady at £24 10s. to £25 per ton.

Arsenic.—Business has been very quiet, and producers have reduced the quotation for Cornish white to £32 7s. per ton delivered station London.

Bismuth.—The leading interests continue to ask 7s. 6d. per lb.

Cadmium.—The price has eased to about 5s. 9d. to 6s. per lb.

Aluminium.—Home producers quote £120 for home and £125 for export business, but there has been some foreign material offering below these figures.

Nickel.—The leading producers continue to quote £190 per ton for home and export business.

Cobalt Metal.—The quotation is still 15s. to 16s. per lb.

Cobalt Oxide.—Business is quiet, with black oxide steady at 12s. and grey unaltered at 13s. 6d. per lb.

Platinum and Palladium.—The market has kept steady. Prices are : manufactured platinum £20, raw £17 per oz. ; manufactured palladium £20, raw £15.

Quicksilver.—The trend of prices has been easier, the chief interests having reduced their price, and the present value is about £10 5s. to £10 7s. 6d. per bottle.

Selenium.—Sellers quote 10s. 6d. to 13s. per lb.

Tellurium.—The price is steady at 80s. to 90s. per lb.

Sulphate of Copper.—The quotation is a little firmer at £30 to £32 for home and export.

Manganese Ore.—There has been a rather easier tone, and Indian grades are nominal at 1s. 1½d. per unit c.i.f. U.K.

Tungsten Ore.—Business is dull, with the present quotation for 65% WO_3 at 13s. to 13s. 3d. per unit c.i.f.

Molybdenite.—Sellers quote 37s. 6d. to 42s. 6d. per unit c.i.f.

Chrome Ores.—The price has been steady at £4 10s. c.i.f.

Silver.—The price of spot bars on August 2 was 38⅞d., but Chinese and Indian selling had a depressing influence, and the quotation sagged to 36¼d. on the 9th. Subsequently there was some Indian buying, which carried the price up to 38⅝d. on the 19th. On the 22nd spot bars reacted to 37¾d., only to recover to 38½d. on the 24th. Towards the end of the month there were small fluctuations, the price closing at 37⅞d. on the 31st

Graphite.—Quotations are nominal, business being rather quiet. Madagascar, 80 to 90%, is steady at £20 to £25 per ton c.i.f.

Iron and Steel.—At the end of the month there were fourteen furnaces in operation in the Cleveland district, and four furnaces in Scotland. Pig iron manufacturers have had their attention chiefly riveted upon the course of fuel prices, and are anxiously awaiting the time when pig iron production can be resumed upon an economic basis. Coke is being offered at 35s. delivered, but pig iron makers are not inclined to look at anything above 30s. The official home trade minimum price of No. 3 Cleveland is still 120s., but sellers ask 135s. Export business is quite stagnant. Hematite is a more active market and supplies are scarce, makers not being disposed to resume production on any large scale until fuel is cheaper. Prices are firm at 160s. for the home trade and 150s. for export. British steel has continued under the influence of Continental competition, but German works are filled now for three months ahead. The settlement of the ship joiners' strike here has tended to improve the home position, and orders which were held up on that account and on account of the coal strike are now being placed. An all-round reduction of 20s. was made in home trade steel quotations, but these are still dearer than Continental supplies.

STATISTICS

Production of Gold in the Transvaal

	Rand	Elsewhere	Total	Price of Gold per oz.	
	Oz.	Oz.	Oz.	s.	d.
July, 1920	718,521	17,578	736,099	[illegible]	0
August	683,061	18,479	[illegible]	112	6
September	665,486	16,687	682,173	115	0
October	645,819	16,653	662,472	117	6
November	618,525	15,212	633,737	117	6
December	617,549	14,666	632,215	115	0
Total, 1920	7,949,038	204,587	8,153,625	—	
January, 1921	637,425	14,168	651,593	[illegible]	0
February	573,767	14,370	588,137	103	9
March	656,572	14,551	671,123	103	9
April	665,309	16,073	681,382	103	9
May	671,750	16,026	687,776	103	9
June	663,383	15,107	678,490	107	6
July	[illegible]	[illegible]	[illegible]	112	6

Natives Employed in the Transvaal Mines.

	Gold mines	Coal mines	Diamond mines	Total
July 31, 1920	174,187	13,005	4,521	191,713
August 31	169,263	13,535	4,244	187,042
September 30	163,132	13,716	4,323	181,171
October 31	159,426	13,858	4,214	177,498
November 30	158,773	14,245	3,504	176,522
December 31	159,671	14,263	3,340	177,274
January 31, 1921	165,287	14,541	3,319	183,147
February 28	171,518	14,697	1,612	187,827
March 31	174,364	14,906	1,364	190,634
April 30	172,826	14,908	1,316	189,050
May 31	170,595	14,510	1,302	186,407
June 30	168,152	14,704	1,317	184,173
July 31	[illegible]	[illegible]	1,246	[illegible]

Cost and Profit on the Rand.

Compiled from official statistics published by the Transvaal Chamber of Mines.

	Tons milled	Yield per ton		Work'g cost per ton		Work'g profit per ton		Total working profit
		s.	d.	s.	d.	s.	d.	£
July, 1920	[illegible]	33	6	24	6	9	0	985,058
August	[illegible]	36	11	25	0	11	11	1,226,906
September	1,959,410	38	11	25	6	13	5	1,276,369
October	1,871,140	39	9	26	1	13	8	1,278,385
November	1,799,710	40	2	26	[illegible]	13	1	1,255,749
December	1,797,970	39	11	26	8	13	3	1,193,672
January, 1921	1,895,235	35	0	26	3	8	9	829,436
February	1,575,320	35	6	28	6	7	0	550,974
March	[illegible]	34	5	26	1	8	4	813,636
April	[illegible]	34	5	25	10	8	7	854,533
May	1,955,357	35	3	26	2	9	1	[illegible]
June	[illegible]	35	10	25	10	10	0	[illegible]

Production of Gold in Rhodesia.

	1919	1920	1921
	£	oz.	oz.
January	211,917	43,428	[illegible]
February	[illegible]	[illegible]	40,816
March	[illegible]	45,779	[illegible]
April	213,160	47,000	[illegible]
May	218,057	46,266	[illegible]
June	214,215	45,054	[illegible]
July	214,919	[illegible]	51,564
August	207,339	48,740	—
September	223,719	[illegible]	—
October	[illegible]	47,342	—
November	186,462	46,782	—
December	158,835	46,190	—
Total	[illegible]	[illegible]	325,399

Transvaal Gold Outputs.

	June		July	
	Treated Tons	Yield Oz.	Treated Tons	Yield Oz.
Aurora West	10,640	£15,182*	[illegible]	£15,823†
Brakpan	53,700	20,971	58,000	21,909
City Deep	85,500	36,128	84,000	35,578
Cons. Langlaagte	44,300	[illegible]	42,300	£71,673†
Cons. Main Reef	49,200	16,866	50,700	17,660
Crown Mines	190,000	54,237	201,000	59,092
D'rb'nRoodepoortDeep	27,000	9,195	27,400	9,448
East Rand P.M.	123,500	33,034	127,000	34,252
Ferreira Deep	32,300	10,020	[illegible]	10,022
Geduld	44,500	14,815	45,300	15,655
Geldenhuis Deep	45,668	12,423	51,387	13,324
Glynn's Lydenburg	3,365	£7,710‡	3,630	£7,158§
Goch	17,300	£19,946*	17,000	£20,441†
Government G.M. Areas	129,000	£275,556*	140,000	[illegible]
Kleinfontein	48,900	13,795	50,100	13,743
Knight Central	28,100	68,816	28,600	6,761
Langlaagte Estate	40,200	£65,700*	40,300	£69,991†
Luipaard's Vlei	21,550	£26,866*	22,560	£31,484†
Meyer & Charlton	13,000	£41,056*	13,500	£42,715†
Modderfontein	96,000	45,103	96,000	46,454
Modderfontein B	57,500	32,556	59,000	33,047
Modderfontein Deep	42,600	23,884	42,500	23,978
Modderfontein East	24,100	9,753	26,350	10,172
New Unified	11,200	£13,571*	11,500	£13,536†
Nourse	42,000	13,561	43,400	13,501
Primrose	21,600	£23,814*	22,000	[illegible]
Randfontein Central	123,500	£201,427*	127,000	£211,792†
Robinson	42,000	7,905	38,000	7,571
Robinson Deep	56,300	17,404	60,200	17,759
Roodepoort United	22,200	£24,434*	22,600	£25,514†
Rose Deep	53,500	13,876	54,400	13,292
Simmer & Jack	61,400	14,136	57,500	13,251
Springs	41,500	18,806	40,000	18,572
Sub Nigel	9,500	[illegible]	10,000	5,461
Transvaal G.M. Estates	15,590	£23,282‡	16,010	£25,878§
Van Ryn	32,200	[illegible]	33,400	£50,730†
Van Ryn Deep	51,000	£144,526*	49,300	£148,588†
Village Deep	47,000	15,212	50,000	16,152
West Rand Consolidated	32,000	£48,862	32,000	£49,712†
Witw'tersr'nd (Knights)	37,400	£53,995	37,700	£52,862†
Witwatersrand Deep	34,391	9,513	31,759	9,178
Wolhuter	32,600	7,842	33,500	8,278

* Gold at £5 7s. 6d. per oz. † £5 12s. 6d. per oz. ‡ £5 6s. per oz. § £5 11s. per oz.

Rhodesian Gold Outputs.

	June		July	
	Tons	Oz.	Tons	Oz.
Cam & Motor	11,700	3,661	12,800	4,060
Falcon	15,572	3,381‖	15,718	3,425*
Gaika	3,406	1,271	3,704	1,242
Globe & Phoenix	6,185	5,386	6,079	5,892
Jumbo	[illegible]	485	1,500	483
London & Rhodesian	2,437	£3,051	2,409	£3,170
Lonely Reef	5,350	5,280	5,400	5,180
Planet Arcturus	5,700	2,438	5,840	2,689
Rezende	[illegible]	2,547	5,850	2,582
Rhodesia G.M. & I.	528	279	338	346
Shamva	[illegible]	£43,946§	54,150	[illegible]
Transvaal & Rhodesian	1,550	£5,063†	1,550	£4,400†

* Also [illegible] tons copper. † At par. ‖ Also [illegible] tons copper. § Gold at £5 10s. per oz.

West African Gold Outputs.

	June		July	
	Treated	Value	Treated	Value
	Tons	Oz.	Tons	Oz.
Abbontiakoon	6,550	£10,947*	7,200	£12,476*
Abosso	5,305	2,090	5,767	2,278
[illegible]	—	—	—	—
Ashanti Goldfields	6,692	6,626	7,077	6,085
[illegible]	—	—	—	85
Obbuassi	[illegible]	£2,555†	[illegible]	[illegible]
Prestea Block A	7,177	£13,091*	8,093	£13,006*
Taquah	2,700	1,729	3,000	1,823

* At par. † Including premium.

West Australian Gold Statistics.—Par Values.

	Reported for Export Oz.	Delivered to Mint Oz.	Total Oz.	Total Value £
November, 1920...	128	54,729	54,857	233,017
December	321	58,595	58,916	229,057
January, 1921	523	50,934	51,457	218,574
February	684	26,872	27,556	117,050
March............	10	47,875	47,885	[illegible]
April	607	46,602	47,209	[illegible]
May	474	47,688	51,503	217,485
June	153	28,194	28,347	120,410
July	1,641	44,917	46,558	197,774
August...........	[illegible]	51,731	51,841	[illegible]

Australian Gold Outputs.

1921	West Australia oz.	Victoria oz.	Queensland oz.	New South Wales £
January .	51,458	4,587	4,582	[illegible]
February.	27,557	11,042	9,146	21,575
March ...	47,886	12,383	6,640	24,344
April	47,273	5,954	2,591	34,101
May	48,113	[illegible]	[illegible]	[illegible]
June.....	[illegible]	—	—	11,540
July	—	—	—	[illegible]
August...	—	—	—	[illegible]
September	—	—	—	—
October .	—	—	—	—
November	—	—	—	—
December	—	—	—	—
Total ..	250,634	44,145	24.986	[illegible]

Australasian Gold Outputs.

	June Tons	June Value £	July Tons	July Value £
Associated G.M. (W.A.)	[illegible]	7,658	[illegible]	8,329†
Blackwater (N.Z.)	[illegible]	[illegible]*	[illegible]	5,175*
Bullfinch (W.A.)	—	—	—	—
Golden Horseshoe (W.A.)	[illegible]	5,253‡	10,224	5,332‡
Grt Boulder Pro. (W.A.)	8,743	27,322†	9,188	28,712†
Ivanhoe (W.A.)	15,425	[illegible]‡	15,106	[illegible]
Kalgurli (W.A.)	1,572	4,371‡	2,370	[illegible]
Lake View & Star (W.A.)	[illegible]	[illegible]*	6,582	14,625*‖
Menzies Con. (W.A.) ..	[illegible]	4,309*	[illegible]	5,511
Mount Boppy (N.S.W.)	2,166	[illegible]‡	[illegible]	[illegible]‡
Oroya Links (W.A.) ...	[illegible]	7,420*	[illegible]	7,115*
Progress (N.Z.)	—	—	—	—
Sons of Gwalia (W.A.)	—	—	—	—
South Kalgurli (W.A.)	[illegible]	[illegible]	7,857	12,488
Waihi (N.Z.)	[illegible]	[illegible]‡ [illegible]§	[illegible]	[illegible]‡ [illegible]§
,, Grand Junc'n (N.Z.)	[illegible]	[illegible]‡ 5,792§	5,570	[illegible]‡ [illegible]§
Yuanmi (W.A.)	1,666	4,513*	—	—

* Including premium; † Including royalties; ‡ Oz. gold; § Oz. silver; ‖ At par.

Miscellaneous Gold and Silver Outputs.

	June Tons	June Value £	July Tons	July Value £
Brit. Plat. & Gold (Colombia)	—	[illegible]§	—	[illegible]
[illegible]	—	—		[illegible]
[illegible]	[illegible]	[illegible]*	[illegible]	[illegible]*
El Oro (Mexico)	[illegible]	[illegible]†	[illegible]	[illegible]†
Esperanza (Mexico)	—	[illegible]‡	—	[illegible]‡
[illegible]	[illegible]	[illegible]*	2,150	[illegible]*
Mexico El Oro (Mexico) ..	[illegible]	[illegible]†	—	—
Mining Corp. of Canada .	[illegible]	[illegible]§§	—	—
Oriental Cons. (Korea) ...	—	[illegible]†	—	[illegible]†
Ouro Preto (Brazil)	[illegible]	[illegible]	[illegible]	[illegible]
Plym'th Cons. (Calif'rnia	8,000	8,120	7,200	8,704
St. John del Rey (Brazil)	—	[illegible]*	—	[illegible]*
Santa Gertrudis (Mexico)	[illegible]	[illegible]‡	[illegible]	[illegible]‡
[illegible]	—	—	—	—
Tomboy (Colorado)	[illegible]	[illegible]†	[illegible]	[illegible]†

* At par. † U.S. Dollars. ‡ Profit, gold and silver. ‖ Oz. gold. § Oz. platinum and gold. ** [illegible] §§ Oz. silver.

Nechi (Colombia): [illegible] 19 days to August 22, $21,978 from 117,780 cu. yd.
Pato (Colombia): [illegible] 12 days to August 24, $22,557 from 91,090 cu. yd.

Indian Gold Outputs.

	June Tons Treated	June Fine Ounces	July Tons Treated	July Fine Ounces
Balaghat	3,200	2,342	3,300	2,364
Champion Reef	11,988	4,667	12,250	4,713
Mysore................	17,243	10,506	17,090	10,517
North Anantapur	700	913	700	968
Nundydroog	8,916	[illegible]	9,048	5,337
Ooregum	12,900	8,475	12,900	8,439

Production of Gold in India.

	1917 Oz.	1918 Oz.	1919 Oz.	1920 Oz.	1921 Oz.
January	44,718	41,420	38,184	39,073	34,028
February ...	42,566	[illegible]	[illegible]	[illegible]	32,529
March	44,617	41,719	38,317	38,760	32,576
April	[illegible]	41,504	38,248	37,307	32,363
May........	[illegible]	40,889	38,608	38,191	32,656
June	42,924	41,264	38,359	37,864	32,207
July	[illegible]	[illegible]	[illegible]	37,129	32,278
August	[illegible]	40,496	37,850	37,375	—
September ..	43,207	[illegible]	36,813	35,497	—
October	43,041	39,472	37,138	35,023	—
November ..	42,915	36,984	[illegible]	[illegible]	—
December ..	44,883	40,149	42,643	34,919	—
Total ..	[illegible]	485,236	461,171	444,532	228,647

Base Metal Outputs.

		June	July
Arizona Copper	Short tons copper ...	—	—
British Broken Hill ...	Tons lead conc. ...	—	—
	Tons zinc conc.	—	—
Broken Hill Prop......	Tons carbonate ore	—	—
	Tons lead conc. ...	—	—
	Tons zinc conc.	—	—
Broken Hill South	Tons lead conc.	2,533	4,709
Burma Corporation....	Tons refined lead ..	2,323	3,239
	Oz. refined silver ..	[illegible]	302,499
Hampden Cloncurry ..	Tons copper	—	—
	Oz. gold	—	—
Mount Lyell	Tons copper	451	446
	Oz. silver	14,316	14,479
	Oz. gold	[illegible]	[illegible]
Mount Morgan	Tons Copper	—	—
	Oz. gold	—	—
North Broken Hill ...	Tons lead conc.	—	1,200
	Tons zinc conc.	—	1,170
Rhodesia Broken Hill	Tons lead	1,569	1,575
Sulphide Corporation ..	Tons lead conc. ..	3,222	2,183
	Tons zinc conc	5,320	3,671
Tanganyika	Tons copper	2,736	3,189
Zinc Corporation	Tons zinc conc......	9,315	9,195
	Tons lead conc. ...	865	925

Imports of Ores, Metals, etc., into United Kingdom.

		June	July
Coal	Tons	1,390,824	1,389,981
Iron Ore	Tons	[illegible]	[illegible]
Manganese Ore	Tons	[illegible]	[illegible]
Copper and Iron Pyrites	Tons	3,881	2,933
Copper Ore, Matte, and Prec.	Tons	[illegible]	689
Copper Metal	Tons	[illegible]	[illegible]
Tin Concentrate	Tons	2,174	1,002
Tin Metal	Tons	[illegible]	[illegible]
Lead, Pig and Sheet	Tons	12,163	12,718
Zinc Spelter	Tons	[illegible]	[illegible]
Quicksilver	Lb.	[illegible]	[illegible]
Zinc Oxide	Tons	[illegible]	[illegible]
[illegible]	Cwt.	[illegible]	[illegible]
[illegible]	Cwt.	12,187	[illegible]
[illegible]	Tons	[illegible]	8,561
[illegible]	Tons	5	—
Nitrate of Soda................	Cwt.	19,800	23,130
Petroleum			
Crude	Gallons	7,137,546	13,271,705
Lamp Oil	Gallons	[illegible]	[illegible]
Motor Spirit	Gallons	16,390,602	13,952,940
Lubricating Oil	Gallons	1,953,902	3,545,107
Gas Oil	Gallons	7,181,277	12,666,828
Fuel Oil	Gallons	[illegible]	[illegible]

Output of Tin Mining Companies.

In Tons of Concentrate.

	May	June	July
Nigeria :	Tons	Tons	Tons
Associated Nigerian	—	—	—
Bisichi	28	33	[illegible]
Bongwelli	—	—	—
Champion (Nigeria)	—	—	—
Dua	—	—	—
Ex-Lands	—	—	20
Filani	2	1	—
Gold Coast Consolidated ...		1½	2½
Gurum River	7	10	13
Jantar............	[illegible]	—	—
Jos	4	7	5½
Kaduna	11	10½	15½
Kaduna Prospectors	8¾	10	7¾
Kano	—	—	—
[illegible] Consolidated	-	15	23
Lower Bisichi	3	—	3½
Lucky Chance	—	—	—
Minna	—	—	—
Mongu	32½	35	37
Naraguta	40	38	50
Naraguta Extended	8	20	20
Nigerian Consolidated	6½	9	8
N.N. Bauchi	42	64	65
Offin River............	—	—	—
Rayfield	—	31	37
Ropp............	97	104	118
Rukuba	3	3	4
South Bukeru	10	16	16
Sybu	1¾	1¼	-
Tin Fields	—	—	—
Yarde Kerri	11	9½	6
Federated Malay States :			
Chenderiang............	—	69*	—
Gopeng	83½	86½	89
Idris Hydraulic............	19	13½	17¾
Ipoh	20	5¼	22
Kamunting	—	82*	—
Kinta	35¾	35¼	35¾
Lahat	50¼	52	53½
Malayan Tin	83	86¼	86¼
Pahang	248	240	214
Rambutan	16	15	14
Sungei Besi	36	33	47
Tekka	36	36	37
Tekka Taiping	10½	21½	20
Tronoh	21	26	32
Cornwall :			
East Pool	—	—	—
Geevor	—	—	—
South Crofty	—	—	—
Other Countries :			
Aramayo Francke (Bolivia) .	161	165	—
Berenguela (Bolivia)	28	28	28
Briseis (Tasmania)	6	9	—
Deebook Ronpibon (Siam) ..	33	32	23
Leeuwpoort (Transvaal)	—	71*	—
Macready (Swaziland)	—	19*	—
Renong (Siam)	107	91	75
Rooiberg Minerals (Transvaal)	50	55	50
Siamese Tin (Siam)	120	124	134½
Tongkah Harbour (Siam) ...	54	98	[illegible]
Zaaiplaats (Transvaal)	13	10	—

* Three months. † Tributers.

Nigerian Tin Production.

In long tons of concentrate of unspecified content.

Note.—These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual outputs.

	1916	1917	1918	1919	1920	1921
	Tons	Tons	Tons	Tons	Tons	Tons
January	531	667	678	613	547	438
February	528	646	668	623	477	370
March	547	655	707	606	565	445
April	486	555	584	546	467	394
May	556	509	525	483	383	337
June	510	473	492	484	435	423
July	[illegible]	479	545	481	484	[illegible]
August	498	551	571	616	447	—
September	535	[illegible]	520	561	528	—
October	584	578	491	625	628	—
November ..	679	621	472	536	544	—
December	654	655	518	511	577	—
Total	6,594	6,927	6,771	6,685	6,622	[illegible]

Production of Tin in Federated Malay States.

Estimated at 70% of Concentrate shipped to Smelter Long Tons

	1917	1918	1919	1920	1921
	Tons	Tons	Tons	Tons	Tons
January	[illegible]	3,030	3,765	4,265	3,298
February	[illegible]	3,197	2,734	3,014	3,111
March	[illegible]	2,609	2,819	2,770	2,190
April	3,251	[illegible]	2,858	2,606	2,692
May	3,413	3,332	3,407	2,741	2,884
June	3,489	3,070	2,877	2,910	2,752
July	3,253	3,373	3,756	[illegible]	3,756
August	3,413	3,259	2,956	2,786	—
September	3,154	3,157	3,161	2,734	—
October	3,436	2,870	3,221	2,837	—
November	3,300	3,132	2,972	2,573	—
December	3,525	3,022	2,409	2,838	—
	39,833	37,370	36,935	34,928	22,216

Stocks of Tin.

Reported by A. Strauss & Co. Long Tons.

	June 30	July 31	Aug. 31
Straits and Australian Spot	1,931	1,936	1,811
Ditto, Landing and in Transit ...	135	250	590
Other Standard, Spot and Landing	4,279	4,388	3,994
Straits, Afloat	1,210	1,355	1,025
Australian, Afloat	90	135	190
Banca, in Holland	3,780	4,244	4,003
Ditto, Afloat	485	351	897
Billiton, Spot	528	423	327
Billiton, Afloat	159	38	100
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	585	305	650
Total Afloat for United States ...	1,225	3,906	3,689
Stock in America	2,546	2,521	1,761
Total	16,953	19,852	19,037

Shipments, Imports, Supply, and Consumption of Tin.

Reported by A. Strauss & Co. Long tons.

	June	July	August
Shipments from :			
Straits to U.K.	320	1,340	995
Straits to America	600	2,420	1,580
Straits to Continent	505	215	590
Straits to other places	250	325	950
Australia to U.K.	25	150	75
U.K. to America	200	975	490
Imports of Bolivian Tin into Europe............	724	221	587
Supply :			
Straits............	1,425	3,975	3,165
Australian	25	150	75
Billiton	273	55	275
Banca	1,170	1,284	965
Standard	263	1,228	928
Total	3,156	6,692	5,409
Consumption :			
U.K. Deliveries	1,361	1,224	2,004
Dutch ,, ...	388	321	389
American ,, ...	1,590	1,525	3,320
Straits, Banca & Billiton, Continental Ports, etc.	631	713	511
Total	[illegible]	3,793	6,224

Outputs Reported by Oil-producing Companies.

		June	July
Anglo-Egyptian	Tons..	13,529	14,682
Anglo-United	Barrels	9,660	9,900
Apex Trinidad	Barrels	16,985	22,225
Astra Romana	Tons..	22,358	22,234
British Burmah	Barrels	69,020	79,569
Caltex	Tons..	—	13,340
Dacia Romana	Tons..	236	236
Kern River	Barrels	91,157	93,421
Lobitos	Tons..	8,845	9,323
Roumanian Consol	Tons..	1,115	2,053
Santa Maria	Tons..	1,228	1,371
Steaua Romana	Tons..	17,704	—
Trinidad Leaseholds	Tons..	11,300	18,892
United of Trinidad	Tons..	3,402	11,000

Quotations of Oil Companies' Shares.

Denomination of Shares £1 unless otherwise noted.

	Aug. 5, 1921			Sept. 6, 1921		
	£	s.	d.	£	s.	d.
Anglo-American	4	5	0	4	0	0
Anglo-Egyptian B	1	8	9	1	10	0
Anglo-Persian 1st Pref.	1	2	6	1	1	6
Anglo-United, Wyoming		3	9		3	9
Apex Trinidad	1	17	6	2	0	0
British Borneo (10s.)		12	6		11	3
British Burmah (8s.)		17	6	1	0	0
Burmah Oil	6	2	6	5	15	0
Caltex ($1)		4	6		3	9
Dacia Romano		17	6	1	1	3
Kern River, Cal. (10s.)		19	6		18	6
Lobitos, Peru	4	2	6	3	17	6
Mexican Eagle, Ord. ($5)	5	6	3	5	2	6
,, ,, Pref. ($5)	5	2	6	4	17	6
North Caucasian (10s.)		17	6		16	3
Phœnix, Roumania		9	6		8	9
Roumanian Consolidated		10	3		11	0
Royal Dutch (100 gulden)	43	0	0	40	0	0
Scottish American		3	0		2	6
Shell Transport, Ord.	5	2	6	4	17	6
,, ,, Pref. (£10)	8	10	0	8	2	6
Trinidad Central	3	11	3	3	2	6
Trinidad Leaseholds	2	5	0	1	18	9
United British of Trinidad		17	6		16	3
Ural Caspian		17	6		16	3
Uroz Oilfields (10s.)		6	6		5	3

Dividends Declared by Mining Companies.

Date	Company	Par Value of Shares	Amount of Dividend
Sept. 8 ...	Balaghat	Pr 10s.	1s. 6d. less tax.
		O. 10s.	6d. less tax.
August 17.	Kinta Tin	£1	5% tax paid.
Sept. 8 ...	Mysore	10s.	1s. less tax.
August 30.	Nechi Mines	Pr. 10s.	1s. 3d. less tax.
Sept. 8 ...	North Anantapur	Pr. £1	1s. 6d. less tax.
		O. £1	1s. 6d. less tax.
Sept. 7 ...	Nundydroog	10s.	6d. less tax.
August 30.	Oroville Dredging	£1	9d. tax paid.
August 31.	Ouro Preto	Pr. £1	10% less tax.
August 30.	Pato Mines	£1	7s. less tax.
August 10.	Rambutan	£1	8d. less tax.
August 16	Witbank Colliery	£1	15% less tax.
August 29.	Zinc Corporation	Pr. £1	2s. less tax.

PRICES OF CHEMICALS. September 8.

These quotations are not absolute; they vary according to quantities required and contracts running.

		£	s.	d.
Acetic Acid, 40%	per cwt.		19	0
,, 80%	,,	1	18	0
,, Glacial	per ton	44	0	0
Alum	,,	16	0	0
Alumina, Sulphate	,,	14	10	0
Ammonia, Anhydrous	per lb.		2	2
,, 0·880 solution	per ton	30	0	0
,, Carbonate	per lb.			4
,, Chloride, grey	per ton	37	0	0
,, ,, pure	per cwt.	3	5	0
,, Nitrate	per ton	45	0	0
,, Phosphate	,,	70	0	0
,, Sulphate	,,	13	7	0
Antimony, Tartar Emetic	per lb.		2	0
,, Sulphide, Golden	,,		1	5
Arsenic, White	per ton	30	0	0
Barium Carbonate	,,	10	0	0
,, Chlorate	per lb.			11
,, Chloride	per ton	14	0	0
,, Sulphate	,,	8	0	0
Benzol, 90%	per gal.		3	0
Bisulphate of Carbon	per ton	56	0	0
Bleaching Powder, 35% Cl.	,,	16	0	0
,, Liquor, 7%	,,	6	0	0
Borax	,,	31	0	0
Boric Acid Crystals	,,	65	0	0
Calcium Chloride	,,	10	0	0
Carbolic Acid, crude 60%	per gal		1	7
,, ,, crystallized, 40	per lb.			6½
China Clay (at Runcorn)	per ton	4	10	0
Citric Acid	per lb.		2	5
Copper, Sulphate	per ton	30	0	0
Cyanide of Sodium, 100%	per lb.			11¼
Hydrofluoric Acid	,,			7½
Iodine	per oz.		1	0
Iron, Nitrate	per ton	9	0	0
,, Sulphate	,,	4	0	0
Lead, Acetate, white	,,	45	0	0
,, Nitrate	,,	48	0	0
,, Oxide, Litharge	,,	41	0	0
,, White	,,	44	0	0
Lime, Acetate, brown	,,	8	0	0
,, ,, grey 80%	,,	11	0	0
Magnesite, Calcined	,,	21	0	0
Magnesium, Chloride	,,	14	0	0
,, Sulphate	,,	8	0	0
Methylated Spirit 64° Industrial	per gal.		5	3
Nitric Acid, 80° Tw.	per ton	31	0	0
Oxalic Acid	per lb.			7½
Phosphoric Acid	per ton	40	0	0
Potassium Bichromate	per lb.			10
,, Carbonate	per ton	26	0	0
,, Chlorate	per lb.			5
,, Chloride 80%	per ton	17	0	0
,, Hydrate (Caustic) 90%	,,	31	0	0
,, Nitrate	,,	49	0	0
,, Permanganate	per lb.		1	3
,, Prussiate, Yellow	,,		1	3
,, ,, Red	,,		2	3
,, Sulphate, 90%	per ton	16	0	0
Sodium Metal	per lb.		1	4
,, Acetate	per ton	24	0	0
,, Arsenate 45%	,,	44	0	0
,, Bicarbonate	,,	10	10	0
,, Bichromate	per lb.			7
,, Carbonate (Soda Ash)	per ton	15	0	0
,, ,, (Crystals)	,,	7	0	0
,, Chlorate	per lb.			4
,, Hydrate, 76%	per ton	26	15	0
,, Hyposulphite	,,	16	0	0
,, Nitrate, 96%	,,	18	10	0
,, Phosphate	,,	22	0	0
,, Prussiate	per lb.			7
,, Silicate	per ton	11	15	0
,, Sulphate (Salt-cake)	,,	6	10	0
,, ,, (Glauber's Salts)	,,	5	0	0
,, Sulphide	,,	22	0	0
,, Sulphite	,,	12	10	0
Sulphur, Roll	,,	13	0	0
,, Flowers	,,	13	0	0
Sulphuric Acid, Fuming, 65°	,,	24	0	0
,, ,, free from Arsenic, 144°	,,	6	5	0
Superphosphate of Lime, 30%	,,	6	10	0
Tartaric Acid	per lb.		1	7
Turpentine	per cwt.	3	3	6
Tin Crystals	per lb.		1	5
Titanous Chloride	,,		1	0
Zinc Chloride	per ton	22	10	0
Zinc Oxide	,,	41	0	0
Zinc Sulphate	,,	17	0	0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS:	Sept. 7, 1920 £ s. d.	Sept. 6, 1921 £ s. d.
Rand:		
Brakpan	2 12 6	2 16 3
Central Mining (£8)	8 12 6	7 0 0
City & Suburban (£4)	7 6	2 6
City Deep	2 17 0	2 11 3
Consolidated Gold Fields	1 9 3	1 1 3
Consolidated Langlaagte	17 6	16 3
Consolidated Main Reef	11 6	12 6
Consolidated Mines Selection (10s.)	1 2 6	17 6
Crown Mines (10s.)	2 13 9	2 5 0
Daggafontein	11 0	3 3
Durban Roodepoort Deep	5 9	6 0
East Rand Proprietary	8 9	6 0
Ferreira Deep	10 0	10 0
Geduld	1 18 0	2 10 0
Geldenhuis Deep	7 6	6 0
Government Gold Mining Areas	4 5 0	4 5 0
Johannesburg Consolidated	1 9 0	1 8 0
Kleinfontein	7 3	7 0
Knight Central	4 6	4 6
Knights Deep	6 0	
Langlaagte Estate	16 6	11 0
Meyer & Charlton	4 12 6	4 2 6
Modderfontein (10s.)	3 13 3	3 15 0
Modderfontein B (5s.)	6 16 3	1 10 0*
Modderfontein Deep (5s.)	2 1 3	2 5 0
Modderfontein East	1 2 6	11 6
New State Areas	1 10 0	1 5 0
Nourse	10 0	9 9
Rand Mines (5s.)	2 19 3	2 10 0
Rand Selection Corporation	2 12 6	2 15 0
Randfontein Central	12 6	13 0
Robinson (£5)	7 0	10 0
Robinson Deep A (1s.)	17 6	10 0
Rose Deep	17 0	13 9
Simmer & Jack	3 9	3 0
Springs	2 2 0	2 5 0
Sub-Nigel	17 6	11 3
Union Corporation (12s. 6d.)	17 3	16 9
Van Ryn	17 0	13 0
Van Ryn Deep	3 17 6	3 15 0
Village Deep	10 3	10 0
West Springs	17 6	13 9
Witwatersrand (Knight's)	14 3	13 9
Witwatersrand Deep	8 6	8 6
Wolhuter	4 6	4 0
Other Transvaal Gold Mines:		
Glynn's Lydenburg	13 9	8 6
Sheba (5s.)	1 9	1 9
Transvaal Gold Mining Estates	10 0	9 3
Diamonds in South Africa:		
De Beers Deferred (£2 10s.)	19 5 0	13 5 0
Jagersfontein	4 15 0	3 0 0
Premier Deferred (2s. 6d.)	10 0 0	5 15 0
Rhodesia:		
Cam & Motor	12 0	12 0
Chartered British South Africa	15 9	12 6
Falcon	8 6	5 3
Gaika	14 6	10 9
Globe & Phoenix (5s.)	17 0	13 0
Lonely Reef	2 16 3	2 10 0
Rezende	3 0 0	3 15 0
Shamva	1 16 3	1 12 6
Willoughby's (10s.)	6 0	4 0
West Africa:		
Abbontiakoon (10s.)	2 9	2 9
Abosso	10 6	9 0
Ashanti (4s.)	17 0	15 0
Prestea Block A	2 0	1 9
Taquah	13 9	9 0
West Australia:		
Associated Gold Mines	3 0	2 6
Associated Northern Blocks	3 0	2 6
Bullfinch	3 6	1 0
Golden Horse-Shoe (£5)	15 0	11 3
Great Boulder Proprietary (2s.)	7 3	6 0
Great Fingall (10s.)	1 0	1 6
Hampton Properties	11 3	5 0
Ivanhoe (£5)	18 9	16 3
[illegible]	15 [illegible]	12 [illegible]
Lake View Investment (1s.)	16 [illegible]	8 [illegible]
[illegible]	[illegible]	3 [illegible]
South Kalgurli (10s.)	[illegible]	[illegible]

GOLD, SILVER, *cont.*	Sept. 7, 1920 £ s. d.	Sept. 6, 1921 £ s. d.
Others in Australasia:		
Blackwater, New Zealand	8 9	2 6
Consolidated G. F. of New Zealand	3 9	2 6
Mount Boppy, N.S.W. (10s.)	5 0	2 0
Progress, New Zealand	1 9	2 6
Waihi, New Zealand	1 13 9	1 1 3
Waihi Grand Junction, New Z'land	10 0	8 9
America:		
Buena Tierra, Mexico	10 0	2 6
Camp Bird, Colorado	13 3	4 0
El Oro, Mexico	13 6	10 0
Esperanza, Mexico	14 3	17 6
Frontino & Bolivia, Colombia	10 0	6 3
Le Roi No. 2 (£5), British Columbia	5 0	2 6
Mexico Mines of El Oro, Mexico	6 17 6	4 10 0
Nechi (Pref. 10s.), Colombia	9 3	4 6
Oroville Dredging, Colombia	1 2 6	1 3 9
Plymouth Consolidated, California	10 0	10 0
St. John del Rey, Brazil	15 6	13 9
Santa Gertrudis, Mexico	1 3 6	7 0
Tomboy, Colorado	8 9	5 0
Russia:		
Lena Goldfields	17 6	8 9
Orsk Priority	10 0	5 0
India:		
Balaghat (10s.)	8 6	7 3
Champion Reef (2s. 6d.)	2 9	1 0
Mysore (10s.)	17 0	11 3
North Anantapur	4 3	3 9
Nundydroog (10s.)	10 6	7 3
Ooregum (10s.)	13 6	12 6
COPPER:		
Arizona Copper (5s.), Arizona	2 10 0	1 10 0
Cape Copper (£2), Cape and India	1 2 6	17 6
Esperanza, Spain	5 0	5 0
Hampden Cloncurry, Queensland	15 0	6 3
Mason & Barry, Portugal	1 10 0	1 10 0
Messina (5s.), Transvaal	5 6	3 6
Mount Elliott (£5), Queensland	1 5 0	13 9
Mount Lyell, Tasmania	1 3 0	13 0
Mount Morgan, Queensland	18 3	12 6
Namaqua (£2), Cape Province	1 10 0	15 0
Rio Tinto (£5), Spain	32 10 0	31 10 0
Russo-Asiatic Consd., Russia	9 6	10 0
Sissert, Russia	11 3	7 6
Spassky, Russia	17 6	10 0
Tanganyika, Congo and Rhodesia	1 15 0	1 1 3
LEAD-ZINC:		
Broken Hill:		
Amalgamated Zinc	1 8 9	15 0
British Broken Hill	2 0 0	18 9
Broken Hill Proprietary	3 3 9	1 17 6
Broken Hill Block 10 (£10)	1 2 6	10 0
Broken Hill North	2 11 3	1 8 9
Broken Hill South	2 10 0	1 6 3
Sulphide Corporation (15s.)	17 0	11 3
Zinc Corporation (10s.)	18 0	8 9
Asia:		
Burma Corporation (10 rupees)	9 17 6	6 3†
Russian Mining	10 0	5 6
Rhodesia:		
Rhodesia Broken Hill (5s.)	11 0	6 0
TIN:		
Aramayo Francke, Bolivia	3 0 0	1 7 6
Bisichi (10s.), Nigeria	10 6	5 9
Briseis, Tasmania	4 3	2 6
Dolcoath, Cornwall	3 3	9
East Pool (5s.), Cornwall	10 0	3 6
Ex-Lands Nigeria (2s.), Nigeria	3 0	1 3
Geevor (10s.), Cornwall	10 0	2 6
Gopeng, Malay	1 15 0	1 12 6
Ipoh Dredging, Malay	17 6	10 0
Kamunting, Malay	2 10 0	1 3 9
Kinta, Malay	2 2 6	1 12 6
Malayan Tin Dredging, Malay	1 17 6	1 5 0
Mongu (10s.), Nigeria	17 0	11 3
Naraguta, Nigeria	10 0	15 0
N. N. Bauchi, Nigeria (10s.)	5 0	2 0
Pahang Consolidated (5s.), Malay	11 3	5 6
Rayfield, Nigeria	8 0	3 0
Renong Dredging, Siam	2 0 0	1 5 0
Ropp (4s.), Nigeria	8 6	6 0
Siamese Tin, Siam	3 1 3	1 17 6
South Crofty (5s.), Cornwall	12 3	4 6
Tehidy Minerals, Cornwall	15 0	6 3
Tekka, Malay	1 3 0	17 6
Tekka-Taiping, Malay	1 5 0	1 1 3
Tronoh, Malay	1 15 0	1 6 0

* New Shares. † 1-rupee shares [illegible]

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also notices of new books and pamphlets, lists of patents on mining and metallurgical subjects, and abstracts of the yearly reports of mining companies.

THE PRINCIPLES OF COPPER LEACHING

The June *Bulletin* of the Canadian Institute of Mining and Metallurgy contains a paper by Frank E. Lathe, chief chemist of the British America Nickel Corporation, on the "Principles of Leaching and Precipitation of Copper." We reproduce this paper practically in full.

Ten or fifteen years ago hydro-metallurgists were predicting a bright future for leaching processes. Many different methods had been worked out satisfactorily on an experimental scale, and all seemed ready for their commercial application. About that time, however, oil flotation came to the fore, and though not even yet understood thoroughly as far as theory is concerned, it at once proved a great commercial success. In fact, its conspicuous achievements relegated leaching to the background. The chief reason why flotation made such rapid progress in comparison with leaching is that the former fits in well with ordinary gravity concentration, in fact, helps it out where it is weakest, in the treatment of slimes. Leaching, on the other hand, is not well adapted to slime treatment, and involves a separate plant, with new apparatus, new chemistry, and new methods of control. As a result, flotation has advanced more rapidly than leaching, but both have now become so firmly established that the metallurgists who would keep abreast of modern progress must study both carefully. In considering the possibility of leaching a particular ore or tailing, there are important points to be investigated. The present paper is an attempt to answer the questions in the light of the recent success of several large plants.

In Table I will be found a list of the principal leaching plants in operation in America during 1920, with classified information about each. In addition to these, several companies are practising heap-leaching of very low-grade ores on a moderate scale, and many processes are being investigated.

The various operations through which an ore may pass will now be taken up one at a time, and the principal points considered in some detail.

Crushing.—Many factors influence the decision as to the best size for leaching purposes. For heap-leaching, where the operation is expected to require a year or two to go to completion, pieces up to several inches in diameter will be satisfactory. Where ore is leached in tanks, however, overhead expense is considerable, and time becomes an important matter.

Fine crushing possesses the following advantages:

(1) It sets free the copper minerals more perfectly and hence tends to improve the extraction.

(2) It increases the capacity of the plant by shortening the time necessary to dissolve the copper.

(3) If the solvent is sulphuric acid, as is usually the case, less of it will be required. The reason for this is as follows. When coarse pieces of ore are

TABLE I.—PRINCIPAL COPPER LEACHING PLANTS IN AMERICA.

No.	Company	Location	Tons Daily Cap'y.	Material Treated	Gangue	Chief Copper Minerals	Preliminary Treatment	Solvent	Preci-pitant	References
1	Anaconda	Anaconda, Montana	2,000	Tailing (sand)	Quartz-monzonite	Chalcocite, chalcopyrite enargite, bornite	Roasting	Sulphuric acid	Scrap iron	Mathewson, E. & M. J., 1915, vol. 99, page 723. Laist and Aldrich, Trans. A.I.M.E., vol. 55, page 866.
2	Calumet and Hecla	Lake Linden, Michigan	4,000	Tailing	Basalt and conglomerate	Native copper	Crushing to 28 mesh, and desliming	Ammonium carbonate	heat	Benedict, E. & M. J, 1917, vol 104, page 44.
3	Chile Exploration	Chuquicamata, Chile	15,000	Ore	Granodiorite	Brochantite chalcanthite, natrochalcite	Crushing to half inch	Sulphuric acid	Electrolysis	Papers by G. L. Oldright, J. J. Fleurnoy and J. B. Wise, read before the Chuquicamata Technical Society. Personal notes.
4	Kennecott	Kennecott, Alaska	700	Tailing	Dolomitic limestone	Malachite, azurite	Partial desliming	Ammonium hydrate	Heat	Lawrence, E. & M. J., 1917, vol. 104, page 781. Eddy, E. & M. J. 1919, vol. 107, page 1,162.
5	New Cornelia	Ajo, Arizona	5,000	Ore	Monzonite porphyry	Malachite, cuprite, chrysocolla	Crushing to half inch	Sulphuric acid	Electrolysis and scrap iron	Morse and Tobelmann, Trans. A.I.M.E., vol. 55, page 830. Tobelmann and Potter, Trans. A.I.M.E., vol. 60, page 22. MacKay, Bull. A.I.M.E., Sept., 1919
6	Utah Copper	Garfield, Utah	2,000	Ore	Monzonite prophyry	Malachite, azurite	Crushing to half inch	Sulphuric acid	Scrap iron	Rickard, M. & S. P., Dec. 1918.

[illegible] the copper minerals [illegible] this time has [illegible] As the solvent action progresses towards the centre of these pieces it becomes slower and slower, and the acid is meantime [illegible] with the leached outer [illegible] will therefore be neutralized by the basic gangue minerals, while if the ore had been crushed finer the acid would have been drawn off before much of this neutralization had taken place.

(4) It will result in less fouling of the solutions, for the same reason that acid consumption is lowered.

On the other hand, if the ore is crushed unnecessarily fine, there are the following disadvantages:

(1) Considerable expense in crushing will be involved.

(2) Excessive dust will be caused in the crusher building, with consequent injury to the workmen. As a preparation for leaching, crushing is done dry when possible, for reasons which will be apparent later.

(3) The dust losses will be considerable whenever the ore is handled, in the crusher building, on conveyors, and particularly when dropped from loading bridges into leaching tanks. This may appear to be an unimportant detail, but as the fines are usually richest the loss is sometimes sufficient to be seen on the monthly balance-sheet for copper.

(4) Slimes leach poorly, unless they can be agitated, which is not done in any commercial plant yet constructed. Extraction is usually best on fine sands.

(5) Channeling in the tanks may result, so that slimes will interfere with the extraction even on the coarser sizes.

(6) More moisture will be retained after the leaching and washing operations are completed, with consequent loss as water-soluble copper.

Where copper minerals occur mainly in cracks, and joint-planes in the ore, as at Chuquicamata, Ajo, and elsewhere, crushing does not need to be finer than ½ in. in order to give a good extraction. At Lake Linden, on the other hand, the *minus* $\frac{3}{16}$ in. tailing has to be further ground until it will pass a 28-mesh screen. At Anaconda 75 to 80% of the sand tailing being treated will pass 20-mesh, and no further grinding is necessary.

The crushing machinery used in preparing ore for leaching does not differ greatly from that found in ordinary gravity-concentration plants. The horizontal Symons disc crusher is the favourite for intermediate work, while rolls and the vertical Symons are also used to some extent. Vertical Symons and fine rolls reduce to half-inch. At the Calumet and Hecla pebble mills are used for fine grinding.

A device has recently been installed at Chuquicamata for overcoming the dust nuisance in the crusher building. Dust is removed by fans and conducted through pipes to a large wooden settling chamber, from which the collected dust is flushed to the leaching tanks.

De-sliming.—If ½ in. ore is being leached, no de-sliming is required before sulphuric acid leaching. The Anaconda plant treats a tailing which contains no great amount of slime, hence percolation is good. The feed is partially de-slimed at Kennecott, and more completely at Lake Linden, where *minus* 200-mesh material is carried off in the overflow from V-shaped settling tanks. Such slimes cannot be leached well without agitation, but may be treated by flotation.

Roasting.—On account of the expense, this step will of course be omitted if possible, and many operators of the present day would say that the necessity of roasting an ore debarred leaching processes altogether. This conclusion is by no means justified. The Anaconda Company roasts tailing with 3·3% of coal, and makes a profit when handling material as low as 0·5% copper. That being the case, there is no reason why leaching should be considered out of the question simply because the copper minerals in the ore are not soluble in sulphuric acid.

When roasting is used as a preparation for leaching, the combined process will in many instances become a serious competitor of flotation. Roasting and leaching have even been made the subject of large-scale experiments on such material as flotation or other concentrates, and it is claimed that these mixed sulphides may be roasted to make soluble 95% of the copper and not more than 1% of iron, in which case electrolytic precipitation should be possible.

The chief objects of roasting are to increase the solubility of the copper and decrease that of the gangue. Copper sulphides are almost insoluble in ordinary leaching solutions, while those of iron are often fairly soluble. In a general way the opposite is true of the oxides. Roasting therefore brings about these two desirable ends, and in addition agglomerates the fine particles so that percolation takes place more readily. In some cases certain impurities like arsenic and antimony are partially volatilized at the same time.

Free access of air is of course necessary for oxidation. In addition to this, temperature control is important. At a low heat sulphates are formed of both copper and iron, and the most desirable temperature is one at which the latter readily breaks up into sulphur trioxide and iron oxide, but at which the copper sulphate is not decomposed. This is about 550° C. Laist states that if the temperature rises too high some of the copper will become insoluble in all acids except hydrofluoric. This will not take place, however, until the temperature is higher than that necessary to decompose copper sulphate, which is 650–700° C. If the heat is sufficient to sinter the sulphides, the copper is likely to be found partly as undecomposed sulphide, half fused, and partly as oxide, but not at all as sulphate, which is the most desirable form if acid consumption is to be kept down.

Chemicals are sometimes added, either to the charge or to the roasted product. Of these the most common is ordinary salt, the presence of which renders much of the copper soluble in chloride solutions, even in the absence of acid, and is especially useful in converting silver and gold into chlorides, in which form they also are readily soluble. In addition, the presence of salt increases the oxidizing action of the air. When leaching was first begun at Anaconda, about 1·5% of salt was added after the roasting operation was complete to increase the extraction of silver, but its use was discontinued some two years ago, chiefly on account of the increased cost of salt delivered at Anaconda.

As Anaconda has the only large-scale plant roasting ore or tailing as a preparation for leaching, a brief description of that plant may be of interest. Roasting is carried out in six-hearth modified McDougall furnaces, 20 ft. in diameter, and fired with coal on the third hearth. The temperature of this hottest hearth is about 535° C., control being

made easy by means of a series of recording pyrometers. Sulphur in the feed is a little over 2%, and this is reduced to about ½%, a part of which is present in the roasted material as soluble sulphates. Each furnace has a capacity of about 75 tons in 24 hours. As already mentioned above, the coal consumption is only about 3·3%, a part of the heat required being furnished by the oxidation of sulphur and iron.

Solvents.—The ideal solvent would be cheap, easy of transportation, or capable of being manufactured at the plant where used, non-volatile, and easily recoverable from its solutions with accompanying precipitation of the copper in a marketable form. Also, when considered in relation to a particular ore, it should completely dissolve the copper without attacking the gangue.

The standard works on leaching give lists of many solvents, including water, sulphuric acid and sulphates of various metals, hydrochloric acid and many chlorides, ammonia, and ammonium salts, sulphurous acid, nitric acid, and others. None of these comes near to the ideal solvent, and most of them are so far away from it that it is unlikely that they will ever be used in commercial operations on a large scale.

Of the solvents named, sulphuric acid is the best, and about 75% of all leaching at the present time involves its use. It has the advantages that :—

(1) It is the cheapest of all solvents except water.

(2) It can frequently be manufactured at the plant where it is to be used, perhaps utilizing for the purpose waste gases from roasting operations.

(3) It is easily regenerated by electrolysis of the copper-bearing solutions.

(4) The copper recovered is of very high purity, and needs only to go through the ordinary furnace-refining given to all high-grade copper in order to make it suitable for wire-bars.

(5) It is non-volatile, and therefore easily handled.

Sulphuric acid, however, possesses some disadvantages which entirely prevent its use in some instances. For example :—

(1) It does not dissolve metallic copper.

(2) It dissolves only half the copper from cuprite, leaving the remainder in the form of metal.

(3) It readily attacks carbonates of lime and iron, which are frequently present in the gangue of copper ores, causing both a heavy consumption of acid and a contamination of the solutions.

(4) It has some action on oxides and silicates of iron and aluminium, which cause trouble by fouling the solutions.

Ammonia, or ammonium carbonate, is being used at the two modern plants, the Calumet and Hecla and the Kennecott, and it is therefore worth while examining its suitability as a solvent. On the one hand : (1) It is expensive. (2) It is not possible to regenerate it by electrolysis of the solutions. (3) The copper recovered from ammoniacal solutions requires further treatment. (4) It is volatile, and therefore difficult to handle. These disadvantages show that ammonia cannot hope to compete with sulphuric acid in the field where the latter is suitable. But ammonia, on the other hand : (1) Dissolves metallic copper readily. (2) Completely dissolves cuprite. (3) Does not attack carbonates of lime or iron. (4) Does not attack compounds of ferric iron or alumina. (5) Is very perfectly recovered by distillation, fouling of solutions being therefore impossible.

Ammonia, therefore, fills just the field in which sulphuric acid is useless. This is well illustrated by a consideration of the two plants using ammonia leaching processes. At the Calumet and Hecla, where native copper is dissolved from mill tailing, sulphuric acid could not be used because of its lack of action on the copper. At the Kennecott plant, where copper carbonates occur in dolomitic limestone, sulphuric acid would dissolve the copper readily, and decompose the gangue almost equally well.

Sulphurous acid, that is, an aqueous solution of sulphur dioxide, has been made the subject of a great number of experiments, and it is possible that it may yet be used on a considerable scale, with precipitation of copper by scrap iron or otherwise. In the majority of cases, however, it will pay better to oxidize it to sulphuric acid, which will make possible the electrolysis of solutions and obviate the difficulty arising from fumes.

Ferric salts are good solvents for oxidized or metallic copper, and even for chalcocite. One of the chief advantages of their use is that they do not ordinarily attack the gangue. Difficulties are that where ferric salts are reduced in the process their complete oxidation is not easily brought about, and that precipitation by electrolysis is not possible. Ferric sulphate is used chiefly in heap leaching, with precipitation on scrap iron.

None of the other solvents is of sufficient importance to make its consideration desirable in a brief review like the present.

From the foregoing it will be evident that so far as present practice is concerned sulphuric acid and ammonia have the field very much to themselves. While the others are not likely to be applied on a large scale in the near future it must not be forgotten that even ten years ago a commercial ammonia process seemed very far away.

Sulphuric Acid Process.—Where fine and comparatively uniform material is to be leached no particular attention need be paid to the distribution of the charge in the tanks. This is the case at Anaconda. But when the ore contains pieces varying in size from nearly an inch in diameter to the finest of slime, precautions have to be taken to prevent channels of coarse ore through which an excessive amount of solution might pass, to the detriment of the remainder of the charge. The large tanks are usually rectangular, and are spanned by loading bridges on which run conveyor belts carrying the ore. A moving tripper distributes it uniformly over the full width of the tank. The tanks are usually 10 to 15 ft. in depth, and it is best to make the layer of ore in the tank the full depth in one trip. The coarser material falls to the bottom, so that there is a certain amount of stratification, but this is desirable rather than otherwise. In filling the final end of the tank it is wise to go only so far that the bottom of the ore slope comes near the end wall, and then move the distributor so that the ore falls directly against the wall, going backwards to fill the remaining space. Otherwise there would be a column of the coarser ore against the end, which it is desired to prevent.

It has been suggested that the best method is to charge the ore with solution already in the tank. When tried on a large scale, however, it is found that this practice results in too much classification, and that percolation and solution of the copper are both slower.

There is no part of the leaching process which is more confusing to one not accustomed to it than

the circulation of solutions. Moreover, each plant has its own system, so that it is almost impossible to generalize. For the purposes of this paper the author decided to choose as an illustration the practice that appears to him most rational and of most general application, namely, that of the Chile Exploration Co., at Chuquicamata. The writer distinguishes the various solutions by letters, taken alphabetically in the order in which they are used, from A to F. Thus A is that going from the leaching plant to be purified on its way to the electrolytic tanks, B and C are the two leach solutions put on the ore, and D, E, and F the three wash solutions, to be followed by fresh water. It should be mentioned here that each of these has its own solution tank in which it is stored while not being used on any ore tank, and these solution tanks will be designated by the same letters as the solutions themselves. The solution analyses to be given are only approximate, as they vary considerably. Table II is an illustration of the working of the system to be described.

TABLE II.—LEACHING CYCLE AT CHUQUICAMATA.

Solution.	Cubic Metres On.	Cubic Metres Off.	Solution.
Moisture	100		
B	3,200 }	3,800	A
D	600 }		
C	3,200	3,200	B
D	2,600	3,200	D
E	3,200	3,200	E
F	2,500	2,500	F
Water	1,400	900	(in tailing)
	16,800	16,800	

The first solution put on a fresh tank of ore is B, only moderately high in both copper and acid (Cu, 25 grammes per litre; H_2SO_4, 45 g.p.l.). This is admitted from the bottom, in order to keep the slimes as far away from the filter as possible, and in amount just sufficient to cover the ore well. It is left on the tank from four to eight hours, depending on the requirements of the electrolytic tank-house, and is then drawn off as A (Cu, 55 g.p.l.; H_2SO_4, 20 g.p.l.). As soon as the withdrawal of A is begun it is followed on the tank by some of D, the first wash (Cu, 15 g.p.l.; H_2SO_4, 28 g.p.l.), the amount varying with the estimated grade of the ore charged.

All the solution being drawn off is sent to the A tank until it is down to 30 g.p.l., so that the volume is greater than that of B put on, greater, if the estimate has been correct, by the volume of D used.

After the small volume of D has been added it is followed by a large volume of C (Cu, 13 g.p.l.; H_2SO_4, 80 g.p.l.), which is the spent electrolyte from the tank-house. This strongly acid solution does the most difficult part of the leaching, and is therefore left on the ore for as long as possible, usually about 36 hours. At the end of that time it is withdrawn, becoming the new B solution, and is at the same time followed by wash solution, first the remainder of D, then E (Cu, 8 g.p.l.; H_2SO_4, 12 g.p.l.), F (Cu, 4 g.p.l.; H_2SO_4, 5 g.p.l.), and clean wash water, in rapid succession. In drawing off these solutions the division between them is not made as in the first case, by copper analysis, but by volume, so that the remainder of D, with a small part of E, goes into the D tank, the remainder of E, with a small part of F, into the E tank, and the remainder of F, with all the wash water, into the F tank.

The amount of wash water which can be used is in the long run the sum of the solution discarded in the electrolytic tank-house, evaporated in the circuit and left in the tailing as moisture, less, of course, the original moisture in the ore. At Chuquicamata the last item is very small, but it is worth mentioning because it illustrates why the ore should not be sprinkled to keep down the dust in the crushing plant. In order to keep the water-soluble copper below 0·01% it is necessary to use about 1,300 tons of water per 10,000 ton tank. After washing, a tank is drained 12 to 24 hours, the longer time being especially necessary when but little wash water has been used.

It is not possible to compare methods in use at different plants with perfect fairness unless all the conditions are carefully considered, which is not possible in this paper. However, some points regarding the practice at Ajo may be mentioned here, and Ajo is more nearly comparable than any of the other plants because it also uses electrolytic precipitation of the copper.

At Ajo the acid in the solutions is run much lower, on account of the much greater solubility of the gangue. The first solution on fresh ore in a tank is circulated through that tank until almost neutral. When drawn off it is followed by several leach solutions, with gradually increasing acid, until at the end of a week the acid has risen to 30 g.p.l. In their practice it has been found that the maximum extraction per pound of acid consumed is given by this long treatment with weak solutions, although of course a larger plant is required. The strongest acid solution is followed by the first of four washes. Each of these is circulated on itself for three hours, until the soluble copper remaining in the ore is uniformly distributed through it, and the tank is then drained before the next wash solution is admitted. The water-soluble copper remaining in the tailing is about 0·06% out of a total of 0·28.

Comparing the two systems, the percolation at Chuquicamata is downward except for the first solution, that at Ajo is altogether upward. The Ajo metallurgists state that upward percolation reduces channeling and effects a more rapid extraction of the copper. On the other hand, their method results in ten times as much water-soluble copper in the tailing, which means a loss of two or three tons of metallic copper per tank. The efficiency of the Chuquicamata method is due to the fact that each succeeding wash put on is lower in specific gravity than the previous one, and there is very little mixing of solutions. To one familiar only with the chemical operations of a laboratory the difficulty of mixing solutions of different specific gravity in large tanks is almost incredible In fact, the theory has been advanced in all seriousness that a uniform solution if left undisturbed for some time will tend to stratify, which is the opposite of the teachings of textbooks. The draining method is doomed to inefficiency because of the considerable amount of each solution remaining in the ore when drained. This can at best only be diluted by the succeeding solution. Downward percolation has the additional advantages that it greatly lessens the amount of slime carried over to the solution tanks, and requires

less power, as the solutions find their way down through the ore by gravity. If, however, the ore in the tank be wet at the beginning of the leaching operation it is desirable to admit the first solution from the bottom, in order to make the water rise ahead of it and go to waste until traces of copper appear. As mentioned above, it is for another reason that it is admitted at the bottom at Chuquicamata, namely, to keep the slimes away from the filter.

As for the advantage of continuous percolation over merely allowing the solutions to stand on the ore, this must be determined for each separate plant. In general, low-grade ore does not require continuous percolation, but it may be essential for ore of high grade. The reason seems to be that with richer material it is necessary to circulate in order to bring a sufficient amount of acid in contact with the copper minerals to effect their solution. In such a case continuous percolation has been known to raise the extraction as much as 30 per cent.

An extension of the time of leaching will usually result in better extraction, or, if the acid concentration of the leach solutions be reduced, in a lower acid consumption with equally good extraction. In normal times the saving thus obtained must be balanced against the cost of additional plant required for an extension of the leaching period. During curtailed production, however, the time may be lengthened to great advantage. Thus at Chuquicamata the average extraction for February, 1921, was raised from the normal of 90–92% to 94·15%. A 40% curtailment at Ajo in March, 1919, reduced the acid neutralized per ton of charge from 67·4 to 45.

The percentage of the total copper which can be extracted in leaching will vary considerably, as some copper is nearly always present as sulphide or in some other insoluble form, and all that the leaching plant should be asked to do is to dissolve a satisfactory percentage of the copper which is soluble in sulphuric aid. The percentage of the acid-soluble copper which is dissolved ought not to be under 85 per cent.

Leaching tanks in the larger plants using sulphuric acid as solvent are usually made of reinforced concrete, with a lining of either lead or mastic asphalt. The lead may be protected from mechanical wear by wood. The smaller tanks, of circular form, are more often of wood, with lead linings. Tanks are emptied by several methods: at Garfield and Chuquicamata by Mead-Morrison unloading bridges, which span the tanks, at Ajo by Hulett unloaders, and at Anaconda by flushing out with water. All these methods are proving satisfactory.

Leaching for precipitation on iron does not differ radically from that just given. The chief differences are caused by the fact that one does not have to plan for the recovery of the acid, which is all lost, and that the fouling of solutions is important only in so far as it increases the consumption of acid. To avoid a large consumption of iron and sulphuric acid the solution going to the precipitation plant should be very low in free acid, which attacks iron readily. It is therefore kept on fresh ore long enough to become practically neutralized. Ferric salts also have a solvent action on the iron, but these are not usually present in large amount. At Garfield the general scheme is not unlike that at Chuquicamata, though there is more circulation of the solutions in the tanks by means of a series of air-lifts.

At Anaconda, where precipitation on iron is used and all acid is lost, this loss amounts to about 65 pounds of 60° acid per ton of tailing. At Ajo much of the acid is regenerated in the electrolytic deposition of the copper, as well as in the purification of the solutions by sulphur dioxide, but the acid consumption is some 90 pounds per ton of ore, the larger amount being due to the relatively greater solubility of the gangue. At Chuquicamata there is a very considerable amount of combined sulphuric acid in the ore, so that if no solutions were discarded in the tank-house there would actually be an increase of acid in the system. As it is, the new acid required amounts to only four or five pounds per ton.

Purification of Sulphate Solutions.—Purification is not necessary except as a preparation for electrolysis, for owing to the discarding of all solutions in precipitation on iron there is no cyclic increase of impurities.

Any gangue material soluble in sulphuric acid is liable to increase to the point of saturation. This may do no harm, if it be chemically inert like calcium sulphate; it may not be within commercial control except by discarding a part of the solution, as, for example, nitric acid; or it may be capable of reduction by a comparatively cheap means, as in the case of ferric iron and chlorine.

Ferric iron is the *bête noire* which haunts the copper hydro-metallurgist in his dreams, and turns his hair white before its time. It is mainly responsible for the difficulties of electrolytic work, and has probably caused more failures than all other impurities combined.

It is possible to entirely remove ferric iron from the solution by precipitation with copper oxide, this being produced especially for the purpose or obtained from the ore itself. In the latter case the difficulty is that in order to dissolve the copper completely it is necessary to follow the purified solution with an acid one, which picks up the precipitated ferric oxide for another trip on the merry-go-round. Fortunately iron in the ferrous condition is almost harmless, so the efforts of the metallurgist are usually directed towards methods of reducing it to the ferrous condition instead of eliminating it from the system.

At Ajo the reduction is made by means of sulphur dioxide. This does not act well in a strongly acid solution, so the solution used in the leaching process, as noted above, is made almost neutral before being sent to the reducing towers. It passes through the towers which are filled with a wooden checkerwork, counter-current to the flow of sulphur dioxide produced in roasting pyrite, and a very good absorption is secured. While being reduced to the ferrous condition ferric iron oxidizes sulphur dioxide to sulphuric acid, which is an important gain.

The reduction brought about in the towers brings the ferric iron down from 10 to 2·5 g.p.l. and increases the acid from 4·0 to 16 g.p.l. This is done without saturating the solution with sulphur dioxide to such an extent that it gives much trouble in the tank-house, although it is well to provide for good ventilation where their gas is used.

It was also suggested at Ajo to utilize the cement copper produced in the precipitation-on-iron plant to reduce the ferric iron of the solutions. This was tried and proved successful, but it usually pays to ship the cement copper and use sulphur dioxide reduction.

Chlorine is present in the Chuquicamata ore,

[illegible] agitating the solution with fine cement copper, which at the same time reduces much of the ferric iron present. The cuprous chloride is dissolved in a ferrous chloride solution and then the copper is precipitated on scrap iron, most of the cement copper so formed going back to the dechloridizing plant.

[illegible] This is perhaps the most difficult part of the hydrometallurgy of copper. If the solutions contained nothing but copper and sulphuric acid the operation would be an easy one, but impurities cause no end of trouble, which can be overcome only by persistent effort.

Many different materials have been suggested for the anodes, but only four have been used to any extent.

Graphite, or carbon in some other form, has many strong advocates, but so far has been practically limited to chloride solutions. If used for sulphate solutions the oxygen liberated at the anode will attack it vigorously unless neutralized by some reducing agent like sulphur dioxide. Ferric salts are also extremely corrosive to carbon. But the voltage used is low, and the amount of acid regenerated is very high, so there are great inducements for further experimentation. It is not at all unlikely that it will be used on a large scale when the various difficulties have been overcome.

Lead containing up to 10% of antimony is very satisfactory for pure sulphate solutions, owing to the insolubility of lead sulphate. Even ferric iron has no effect on it. If much chlorine is present, however, these anodes go to pieces rapidly, and their solution is even more rapid with nitric acid in the electrolyte as at Chuquicamata The only trial they have had on a large scale is at Ajo, and there they are giving splendid service. At the end of the first year of operation they were almost as good as new, so it is certain that anode replacement will be a small item.

Chuquicamata, with sulphuric, nitric, and hydrochloric acids in the solutions, has had the most difficult problem. Here both magnetite and ferro-silicon have been used. In the early experimental work it was decided to use fused magnetite anodes made in Germany, and these were installed in the large plant. Then the breaking out of the European war prevented the shipment of a further supply, and ferro-silicon (about 13% Si) was substituted for magnetite. This was much inferior to magnetite chemically, but far better in its mechanical and electrical properties, and cheaper. The war has been over more than two years, but ferrous-silicon anodes are still in use. The company's research laboratory has developed several promising new materials, and may yet be rewarded by an anode which will be a success commercially. The difficulties with ferro-silicon are that it is not entirely insoluble in the solutions used, so that anodes of this material have to be replaced from time to time, and that the iron dissolving contaminates the solution. In fact, the necessity of discarding a large quantity of solution at that plant is due entirely to the solubility of the anodes, for the tailing contains as much iron as the ore itself. Some solution would have to be discarded, in any case, to eliminate the nitric acid, but that does not do so much harm when the ferric iron is low.

The electrolyte employed differs from the electrolyte used in ordinary copper-refining chiefly in the lower acid content and higher impurities. The former is due to the effort to avoid acid consumption by action on the gangue, which would be increased by high acid in the solutions. At Ajo it is further lowered to gain efficiency in the reduction of ferric iron by sulphur dioxide. In order to increase the acid and lower the copper at Chuquicamata the solution from the dechloridizing plant is diluted, before going to the tanks, with some of the solution which has been partly electrolysed and therefore has had a part of its acid regenerated.

The impurities in the electrolyte are those which have not been eliminated by some process of purification of the leaching plant solutions. Ferric iron in the head-tank solution is usually low, because it can be controlled, but the ferrous iron may be high, and this is a latent source of trouble on account of the ease with which it is oxidized. As the total iron increases, the trouble with ferric iron becomes so great that something radical has to be done, and this usually means discarding the solution after removal of the copper. Ferric iron has a very considerable solvent action on the copper deposited, thereby lowering the ampere efficiency and also increasing the voltage. Chlorine up to 0·5 g.p.l. has no great effect on the current efficiency, and a considerable part of it is deposited with the copper; chemically deposited, because electrically it would go to the anode. The small amount of chlorine which may be introduced into solutions in the wash water used has not been found harmful to lead anodes, as was feared before they were given a commercial trial. At Ajo about two-thirds of the chlorine is deposited with each cycle through the tanks. Nitric acid may run up to 15 g.p.l. without doing any serious harm, especially if the ferric iron is low, but at high concentration or in a warm electrolyte it attacks both cathode and anode, at the same time giving off obnoxious fumes in the tank-house.

On account of the high voltage necessary to deposit copper with insoluble anodes, it is not necessary to heat the solutions. In ordinary copper-refining this is done to decrease the ohmic resistance of the electrolyte, but when ferric iron is present it is desirable to have the temperature as low as possible to avoid the solvent action of these impurities on the deposited copper. At Ajo the temperature of the solutions remains about 30° F. above that of the atmosphere, but at Chuquicamata, where the current density and the resistivity of the anode are both higher, the heating is great enough to make necessary a cooling tower through which the electrolyte goes.

In discarding solution from the tank-house to eliminate impurities, the copper may be removed by electrolysis, or by precipitation on iron, or by a combination of these methods. The choice depends chiefly upon the relative cost of electric current and scrap iron, and the means at hand for disposing of the impure electrolytic or cement copper produced. Electrolysis is done at the cost of a greatly reduced current efficiency, while conditions are also bad for precipitation on iron, on account of the acidity of the spent electrolyte. At Chuquicamata electrolysis alone is used, and the impure (arsenical) copper is sent to the anode furnace making soluble anodes for the starting-sheet section of the tank-

house. At Ajo the spent electrolyte is passed over scrap iron, and the cement copper is shipped or used to reduce ferric iron in the solution.

The spent electrolyte may not, however, always be the proper solution to discard. It may be that in the leaching process iron and alumina will actually be precipitated on the ore, only to be picked up again by the strong acid and wash solutions. If as a result the wash solutions contain more iron and less free acid in proportion to the copper content than does the spent electrolyte they can be discarded to advantage. It will mean less copper to precipitate per unit of iron discarded, and less acid lost as well. Also, on account of the lower acidity, the consumption of scrap iron should not be as high as when precipitating copper from spent electrolyte. In addition, the water-soluble copper in the tailing can be kept down by using an extra amount of wash water and then passing this over scrap iron.

The theoretical voltage necessary to decompose copper sulphate with an insoluble anode is 1·22. In practice nothing near this is ever reached, owing chiefly to the solvent action of impurities, but all the factors ordinarily met with in copper refining also play a part. At Ajo, where the current density is low (7·5 amperes per square foot) the voltage is just over two; at Chuquicamata, with anodes of greater resistivity and nearly double the current density, it is about 2·8. The current density should be about that used in ordinary refining under similar cost conditions. A higher current density has been advocated in order to more perfectly overcome the solvent action on the cathodes, but this does not take into account the heating of the solutions with the higher current, which will cause the solvent action to increase in even greater proportion than the amperage.

The current efficiency in a new plant is usually low, not so much on account of difficulties inherent in the process as because it is necessary to start with a green crew. When men have been properly trained for the work it is not unreasonable to look for an efficiency of 80 to 85%. The amount of copper deposited per kilowatt-hour should be 0·7 to 0·9 lb.

The starting-sheet section may be practically the ordinary starting-sheet department of a copper refinery, when soluble anodes are used, as at Chuquicamata, or the starting sheets may be made from the usual tank-house solution, with insoluble anodes, as at Ajo. If the anodes can be provided without too great expense, it will be found advantageous, in most cases, to adopt the former system, owing to the better quality of the sheets produced.

Percipitation on Iron.—This method will usually be adopted in small plants where it is desired to keep the initial expense of construction down to a minimum, and in large-scale operations as well when iron can be obtained as a by-product of the company's shops, as at Anaconda and Garfield. These plants are also favoured by having a ready means of disposing of the cement copper produced. The installation of electrolytic tank-houses should be undertaken only by companies with the best of metallurgical skill at their command.

Precipitation may be done with almost any kind of scrap iron, old tin cans, and old galvanized iron utensils being used in large quantities for the purpose. Sponge iron, that is, iron reduced from its ores at a low temperature, and consequently very porous, would be almost ideal as an iron precipitant, but its production on a commercial scale has not been a part of the practice of any of the large companies. Both the Anaconda and New Cornelia (Ajo) have done extensive experimentation along this line, and it is believed that the difficulties encountered are not insurmountable.

Precipitation formerly took place in launders, which required a fairly large plant and involved difficulties in handling materials. Now, however, the tendency is to precipitate the greater part of the copper in modified tube-mills filled with scrap iron, through which the solution flows on its way to the launders for the final precipitation. This centralizes the handling of both the scrap iron and cement copper, for which machinery can then be used to advantage. The Utah Copper Co., at Garfield, has the most extensive installation of this kind, though it has been practised for some years at Chuquicamata in the recovery of copper from the cuprous chloride.

Theoretically the consumption of iron in the precipitation of copper from cupric solutions is nine-tenths of a pound per pound of copper, and half of that amount from cuprous solutions. Owing, however, to the action of acid and ferric salts, these figures cannot be even closely approached in practice. Twice the theoretical consumption would be more nearly normal in sulphate solutions, with better than that in chloride solutions.

The cement copper is always contaminated with iron and other impurities, so that it will not usually analyse higher than 65 or 70% copper.

Ammonia Leaching.—The success of ammonia leaching may be ascribed chiefly to the overcoming of mechanical difficulties in handling a solvent so volatile, so that the mechanical features of such a plant are specially important. Steel tanks are used by both the Calumet and Hecla and the Kennecott, but these differ considerably in detail. In the former each tank has a removable cover, which is taken off for charging and other operations, while the solution is not on the charge. At Kennecott the covers are dome shaped, and riveted to the tanks, and are made sufficiently strong to withstand an internal pressure of 10 lb. to the square inch. Manholes are provided, as also are others for charging and manipulating the feed distributor and excavator, which are permanent fixtures inside the tanks. The reason for the Kennecott construction is that the washing of the tailing is done with steam under pressure, the system being patented by them. Covered tanks are provided in both places for solution storage.

The chemistry of the operation is simple. At Lake Linden ammonium carbonate is bought, and this, with the oxygen of the air, acts on the metallic copper as follows :—

$$2(NH_4)_2CO_3 + O_2 + 2Cu = 2CuCO_3(NH_3)_2 + 2H_2O$$

This cupric-ammonium carbonate has a solvent action on more copper, producing cuprous-ammonium carbonate :—

$$CuCO_3(NH_3)_2 + Cu = Cu_2CO_3(NH_3)_2.$$

This again is oxidized by the air to cupric-ammonium carbonate :—

$$2Cu_2CO_3(NH_3)_2 + O_2 + 2(NH_4)_2CO_3 = 4CuCO_3(NH_3)_2 + 2H_2O.$$

In this way the air really furnishes all the oxygen required, and the ammonium carbonate and cupric-ammonium carbonate simply act as carriers for it. In plant operation this oxygen is introduced by passing air through the first and second leach

solutions, which have their copper thus converted to the cuprous condition. Any ammonia gas which is carried off during the operation is absorbed in water.

At Kennecott, where the ore is a carbonate, the solution is bought as ammonia, but this is of course rapidly converted into the carbonate. In both plants the ammonia and the carbon dioxide combined with it are recovered by distillation, the compounds being broken up by heat, but again re-forming in the condensers, while copper oxide is precipitated in the residual solution.

The leaching cycle is not radically different from that used in sulphuric-acid leaching, and the same precautions should be observed, except that in this case there is no fouling of solutions to worry about. At Lake Linden two leach and two wash solutions are used, followed by wash water, the quantity of the latter being dependent upon the volume sent to the stills. This will naturally be kept at as low a point as possible, as the cost of steam for distillation is one of the principal items of expense. In washing at Kennecott, steam is introduced at the top, and passes through the charge, being thus preceded by a wash of condensed steam. The ammonia is thus driven out by volatilization. The amount of steam necessary per ton of charge is about 100 lb. at 5 lb. pressure, and some 20 hours are required for the operation.

Theoretically all the ammonia should be recovered. In practice there is lost about one pound per ton at Lake Linden and half that amount at Kennecott. The better recovery at the latter place is due to the steam wash, but it is doubtful whether in the average plant it would pay for the cost of steam consumed. Steam and ammonia account for about 60% of the total cost at both plants. The stills consist of a series of cylinders placed vertically, the copper ammonia solutions passing down while steam ascends. The first cylinders remove nearly all the ammonia, and the second series complete the operation. At first much trouble was experienced owing to the precipitated copper oxide adhering to the stills, but this was overcome by placing in each a revolving scraper to remove it as fast as formed.

The leaching plant at Lake Linden made last year about 11,000,000 lb. of copper, which cost less than six cents a pound up to smelting. The recovery was over 80%. At Kennecott the recovery of oxidized copper was about the same, the cost per ton of tailing somewhat higher and that per pound of copper a little lower, owing to the higher grade of material treated.

Selection of Leaching Processes.—The characteristics of an ore suitable for leaching by one of the methods described are :—

(1) The copper minerals must be soluble in sulphuric acid or ammonia, or capable of being made so by a cheap method, as roasting. This applies to nearly all ores except possibly heavy sulphides.

(2) The gangue minerals must be nearly insoluble in either acid or ammonia, or capable of being made so. This also applies to most ores.

(3) Gold and silver should either not be present in appreciable quantities or should be rendered soluble by a chloridizing roast or leach. It should be mentioned that there is no large-scale plant recovering both copper and precious metals in this way, but such may be expected as a result of future developments.

On account of the strong competition of flotation in handling sulphide ores, the most promising extension of leaching in the near future would seem to be the treatment of the large bodies of partly oxidized ores at present lying idle. These will, of course, require a preliminary roast. And the day may not be far distant when a roasting and leaching process producing electrolytic copper may be found preferable to the usual combination of gravity concentration, flotation, smelting, converting, and electrolytic refining, even on ores which are well adapted to flotation.

Leaching has been applied in the past almost entirely to low-grade material, but this limitation is not imposed by the nature of the process. If it be commercially feasible to roast and leach the tailing from a gravity-concentration plant, it may be even more profitable to similarly treat the ore itself.

When viewed in the light of its financial success, leaching makes an excellent showing. In fact, the profits made by companies handling low-grade ore or tailing are an indication that under suitable conditions leaching costs compare favourably with those of any methods of treatment yet devised.

DRESSING OF WOLFRAM ORES IN QUEENSLAND

Reference was made recently in the MAGAZINE to the mines and dressing plant of the Burma Queensland Corporation, at Wolfram Camp, North Queensland. A detailed description of the mill is given in a paper by W. H. Bowater, showing how the tungsten, bismuth, and molybdenum minerals are separated, appearing in the *Proceedings* of the Australian Institute of Mining and Metallurgy, No. 40, 1920.

A commencement was made with the erection of the first unit of the new mill in August, 1917, and milling and concentrating commenced in February, 1919. The ore is essentially quartz, the richer values occurring in lumps and patches in this quartz. Between the quartz and the granite there is a transition zone, through which the molybdenite is more evenly distributed. The chief minerals are molybdenite, wolfram, metallic bismuth, bismuth sulphide, bismuth carbonate, and, rarely, a little scheelite. The wolfram is of a very friable nature, and, as the quartz gangue contains the molybdenite, a screen must be chosen so that the wolfram is slimed as little as possible and at the same time the quartz reduced as much as possible.

The ore from the company's various mines is delivered by the aerial ropeway into the off-loading bin (see Fig. 1), passing from this bin over No. 1 grizzly with 2 in. openings. The oversize from No. 1 grizzly passes to No. 1 jaw crusher, set to break at 2·5 in., and thence to No. 2 grizzly with 1·5 in. openings. The oversize from No. 2 grizzly passes to No. 2 jaw crusher, set to break at 1·5 in., then joins up with the fines from No. 1 grizzly and No. 2 grizzly, the whole then passing to the intermediate bin. From the intermediate bin the ore is trammed to the battery bins, side-tipping trucks of one-ton capacity being used. The ore is distributed as required for each 5 heads of stamps. At the

Flow-sheet of Burma Queensland Corporation's Mill.

time of writing the first unit of 20 heads of stamps was in commission, arranged in groups of 5 to each box. From the battery bins the ore is automatically fed through Challenge ore-feeders to the stamp boxes. Stamps are of 1,250 lb., run at 100 drops per minute, with from 6 in. to 7 in. drop. The depth of overflow is approximately 10 in. Woven wire screens are used with apertures of 1/10 in. to 1/12 in., the latter for ore richer in molybdenite. The stamp duty varies from 5·5 to 5·8 tons per head per 24 hours. The mortar boxes are set on concrete foundations with a ⅝ in. rubber sheet between the box and concrete. The pulp, passing from the stamper boxes, is automatically sampled before passing to hydraulic classifiers (No. 1 group), one classifier for each 5 heads of stamps. The spigot (⅝ in. diameter) from each classifier passes to its settler (B), the overflow from each classifier joining up and passing to settler (C), the overflow of settler (C) being divided and passing to two settlers (CA). The spigot (½ in. diameter) from each settler (B) passes to Wilfley and Buss tables, one table to each settler. The overflow from settlers (B) joins up and passes to a large settler (D), the spigot (⅝ in. diameter) of which passes to a Wilfley table. The overflow of settler (D) passes to a still larger settler (E), the spigot (⅝ in. diameter) of which is sent to classifier No. 2 group, the overflow being sent to the tailings launder of the group of Wilfley and Buss tables, assisting to flush out this launder. Three products are made on the concentrating tables: bismuth-wolfram concentrates, middlings, and tailings. The bismuth-wolfram concentrates assay 30% to 45% WO_3 and 5% to 7% Bi. The middlings assay approximately 8% to 10% WO_3 and 5% MoS_2, and contain a fair percentage of pyrites. The tailings contain 0·1% to 0·13% WO_3, the percentage of MoS_2 varying, depending on the degree of fineness of stamping.

The concentrates are sent to the drying and magnetic separation room.

The middlings pass to Wheeler pans, thence to

[illegible] classifiers No. 2 group. The spigot of these classifiers ([illegible] in. diameter) pass to Krupp tables, producing bismuth-wolfram concentrates, middlings, and tailings. The bismuth-wolfram concentrates assay 25% to 40% WO_3 and 3% to 5% Bi, and are sent to the drying and magnetic separation room. The middlings from the Krupp tables are elevated back to the Wilfley table dealing with the spigot from settler (D). The overflow from each classifier joins up and passes to a settler (F). The spigot (½ in. diameter) of this settler passes to an Isbell vanner, producing bismuth-wolfram concentrates and tailings. The concentrates, containing 15% to 25% WO_3 and 3% to 4% Bi, are sent to the drying and magnetic separation room. The overflow passes to two settlers (G). The spigot and overflow of settlers (C and CA) also pass to two classifiers (No. 2 group), the spigots ([illegible] in. diameter) of which join up and pass to an Isbell vanner, the overflow of the classifiers passing to settlers (G).

The tailings from the Wilfley and Buss tables are passed to two settlers (CB), the spigots of which join up and are sent to the molybdenite flotation plant (No. 1) sub-unit, the overflow being pumped back to the mill reservoir.

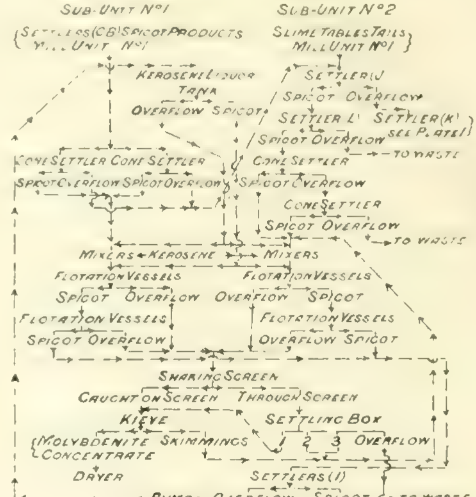
The tailings from the Krupp and vanner tables are passed to a settler (H), the spigot (¾ in. diameter) of which is passed to the molybdenite flotation plant (No. 2 sub-unit), the overflow going to the creek dam.

The spigot of settler (G) is run to slime frames, producing a low-grade concentrate and tailings, the overflow going to the waste settler (L). The tailings join up with the spigot of settler (H) and pass to the molybdenite flotation plant (No. 2 sub-unit). The spigot of settler (K) (see later), together with No. 2 head of the slime frame concentrates, is sent to a buddle (No. 1), the overflow going to waste. No. 1 head of this buddle, together with No. 1 head of the slime frame concentrates, is re-treated in No. 2 buddle. No. 2 head of No. 1 buddle is re-treated in No. 1 buddle, and No. 3 head is sent to waste. No. 1 head of No. 2 buddle is treated on a Luhrig vanner, producing bismuth-wolfram concentrates, middlings, and tailings. The concentrates are sent to the drying and magnetic separation room. The middlings are returned to the vanners, and the tailings sent to waste. No. 2 head of No. 2 buddle is re-treated in No. 1 buddle and No. 3 head sent to waste.

The bismuth-wolfram concentrates are dried, sampled, weighed, and assayed. They are then sized into three grades (through 30 mesh, through 16 mesh, and through 12 mesh) and magnetically separated. Any oversize is crushed and re-sized. Two magnetic separators of the Dalbouze bracket type are employed at work, the current used being 11 amperes at 110 volts. The product from the separators consists of clean wolfram concentrates and a bismuth concentrate containing the bismuth, together with a little wolfram. A small amount of iron residue is also obtained, which contains a small percentage of wolfram. These residues are dressed on a Wilfley table, producing a fairly high-grade wolfram concentrate, which is shipped with the concentrate above. The wolfram and bismuth concentrates from the separators are then ready for shipment.

The molybdenite flotation plant (see Fig. 2) consists of two sub-units, No. 1 dealing with the tailings from the Wilfley and Buss tables, and No. 2 dealing with the tailings from Krupp tables, Isbell vanners, and slime frames.

In No. 1 sub-unit the spigots from settlers (CV) are passed to two settlers of the cone type in order to be dewatered as much as possible. The dewatered pulp is passed to a mixer, the stirring blades revolving 175 r.p.m., the necessary oil required being added in this mixer. From the mixer the pulp is fed to distributors on No. 1 set of four flotation vessels. The flotation vessel is of the cone type, with an approximate diameter of 4 ft. 9 in. and depth 3 ft. 3 in. The distributor occupies 1 ft. 11 in. of the centre of the vessel, leaving 1 ft. 5 in. of the outer diameter of the vessel as flotation area. The spigots of No. 1 set of flotation vessel pass to distributors on No. 2 set, the concentrates passing to a dewaterer. The spigots of No. 2 set are sent to two large settlers (I), the liquor overflowing to the storage reservoir,



Molybdenite Flotation Plant.

and the tails passing to waste, the various overflows joining up at this point and providing the necessary flushing water. The concentrates from No. 2 set of flotation vessels join up with those produced from No. 1 set and pass to the dewaterer. The overflow from the two cone settlers is passed to a large settler (J), the spigot (½ in. diameter) of which is sent to No. 2 sub-unit, the overflow passing to a still larger settler (K). This precaution is taken in case of the overflowing of the two cone settlers, in addition to obtaining a better settlement of the fine material.

In No. 2 sub-unit, the tailings from the Krupp tables, Isbell vanners, slime frames, and spigot of settler (J) are sent to a large settler (L). The spigot (¾ in. diameter) is passed to two cone settlers, the overflow going to waste. The dewatered pulp from the cone settlers is then dealt with as in No. 1 sub-unit, the feed from the mixer passing to distributors on No. 1 set of three flotation vessels and concentrates to the dewaterer. The spigot of No. 1 set of flotation vessels passes distributors on No. 2 set, the concentrates joining up and passing to the dewatered. The spigots of No. 2 set of flotation vessels join up with the spigots of No. 2 set of No. 1 unit, and pass to the settlers (I).

The molybdenite concentrates also join up with that produced from No. 1 sub-unit, and together pass to the dewaterer. The molybdenite dewaterer is a rectangular box approximately 3 ft. long by 2 ft. wide and 6 in. deep. On the bottom of the box is placed 80 mesh screening. The liquor carrying the concentrates is led on to the box, the latter being given a shaking movement. The dewatered concentrate is periodically removed from the screen, the liquor and fine molybdenite passing through the screen into a large 3-compartment box. The fine molybdenite settles in this box, and the liquor overflows to the storage reservoir. The fine molybdenite in No. 1 compartment of this box is periodically removed and dressed in kieves to a marketable concentrate. The fine molybdenite in Nos. 2 and 3 compartments, together with the skimmings from the kieves, are periodically returned to the mixers. As much as possible of the liquor is saved and pumped from the storage reservoir to tanks above the mixers, thus providing liquor for the mixers and overflow of the flotation vessels. Loss in liquor is provided for by adding water when necessary to these tanks. The dewatered molybdenite concentrate is dried and is then ready for market. The concentrate obtained from the screen assays 85% to 94% MoS_2. The dressed concentrate from No. 1 compartment of the box assays 80% to 85% MoS_2, depending on the cleanliness of the water used in the flotation plant and the nature of the ore milled.

CORNISH GEOLOGY

At a meeting of the Royal Cornwall Polytechnic Society held on July 6, E. H. Davison read a paper entitled : "Some Recent Additions to our Knowedge of Cornish Geology." This consisted of a series of notes on new facts regarding the geology of Cornwall, both on the purely scientific side and as regards the economic side of the science, which have come to the author's knowledge during the last eighteen months. In most cases the original observations were made by one or another of his students at Camborne Mining School, sometimes as the result of suggestions made by others, at other times entirely original.

The occurrences described in the paper are as follows :—

(1) A new type of basic igneous rock from Porthglaze Cove, Gurnard's Head.

(2) A type of tourmalinized granite not previously described from Wheal Providence, Carbis Bay.

(3) An unusual form of altered elvan from Carn Menellis district.

(4) The occurrence of platinum in the alluvial gravels of the Lizard.

(5) The occurrence of gold in the Carn Menellis district.

(6) Green Clay on Goonhilly Downs.

(7) Fuller's Earth at Treamble.

(1) In August, 1920, Mr. Castier, who was then a student at the Mining School, and has since gone to the Ouro Preto mine, Brazil, noticed a strange rock at Porthglaze Cove, just to the northeast of Gurnard's Head. The author visited the cove and found in its western corner a basic igneous rock, with patches and lenticular areas of pale coloured more acid material, forming the cliff to a height of about 120 ft. above sea-level and for a distance of about 40 yards to the west. The rock has a black and pink foliated appearance, the black part being composed of hornblende, iron ore, and a little felspar, while the pink part is composed of altered orthoclase felspar with some sphene and apatite. The specific gravity is 2·82, and the general character of the rock reminds one of the Kennack gneiss of the Lizard, and it seems to have originated similarly from a magma composed of imperfectly mixed acid and basic material. The rocks in the immediate neighbourhood of this mixed rock are intruded by granite veins, the granite-slate contact being visible in the cliff 50 yards to the east. It has been suggested that the mixed rock originated as a result of the absorption of the "greenstone" by the granite, but the field relations of the two rocks do not support this view. The author is at present engaged in a thorough examination of the mixed rock, which should throw light on its origin. He has since seen a similar type of greenstone in the Botallack cliffs.

A microscopic study of the rock shows that the coarsely foliated character which is a common feature was the result of movement while the magma was still fluid and not of pressure subsequent to solidification.

(2) Early this year Mr. Simmonds brought the author a specimen of tourmalinized granite from Wheal Providence dumps, Carbis Bay, which has unusual characters. The rock occurred in the dump material, there being several blocks exposed when the dump was being shifted for road material. The rock shows pink orthoclase and quartz with coarsely crystallized prisms of tourmaline and nests of yellowish muscovite with some chlorite. At first sight it appears similar to tourmalinized granite of the luxulyanite type, but the tourmaline occurs in groups of well-developed prisms arranged parallel to one another and not in radiating needles of small size, as is the case in luxulyanite. The presence of the muscovite is another point of difference. The quartz and felspar frequently show pegmatitic intergrowth. The tourmaline also is seen to penetrate the felspar, and all four minerals (quartz, felspar, tourmaline, and mica) seem to have crystallized simultaneously to form a pegmatite.

(3) On a visit to Carn Menellis district last April the author came across a type of altered elvan which has unusual characters. The dyke of elvan (quartz-porphyry) is worked on the hillside just above Carn Menellis church, and is seen in the quarry to be a fine-grained rock of a pale buff colour composed of occasional phenocrysts of quartz and felspar in a fine grained felsitic groundmass. Scattered through the rock here and there are cubic crystals of pyrite which are oxidizing to limonite and are surrounded by a ring of red-brown iron stain. The altered type is of a pale yellowish-green colour which has been brecciated and recemented by quartz showing comb structure. Under the microscope the ground-mass is seen to be composed of an extremely fine-grained mosaic of quartz, chlorite, muscovite, and secondary silica. The original felspar phenocrysts have been entirely removed by silicification, and with the silica lithia micas have been introduced.

(4) When Dr. R. H. Rastall read his paper on "Ore Deposits of Igneous Origin" before the Cornish Institute of Engineers last April he suggested that according to the character of the Lizard rocks they would very probably contain platinum, and he considered that the best place to hunt for the metal would be in the alluvial gravels of the serpentine area. As the outcome of this suggestion two of the students (Messrs. MacPherson and Lamb) visited several localities on the Lizard and collected samples of the river gravels. The concentrate obtained by panning the samples from one locality was assayed and it proved to contain a very small quantity of platinum. They then obtained a prospecting licence and made a more thorough examination of the area, but unfortunately with no satisfactory results. It appears then that platinum undoubtedly occurs in the Lizard district associated with the ultrabasic rocks there, but not in quantities of economic importance. This is what one would expect considering the small amount of real alluvial material in the district.

(5) Another interesting occurrence (but not one which can be claimed as new) was confirmed by Messrs. Kitto and Linne, who, during the study of an alluvial area in the Carn Menellis district, found that the alluvial sands contained gold. This metal has been recorded from the district before, so that this cannot be considered a discovery, but it is interesting as confirming a previous report and as indicative of the wide-spread distribution of small quantities of gold in the county.

(6) Other economic products which are now being worked in the county and which can be considered as additions to the list of Cornish products, are :—

(*a*) The green clay worked in the Mullion district, which can be seen by the side of the high road on Goonhilly Downs to occur near the junction of the ancient Lizard granite and the serpentine.

(*b*) The St. Agnes Pliocene sand, which is now being dug for core sand.

(7) A clay deposit at Treamble, near Perranporth, was discovered by Stephen Clark, of Treamble, about 12 months ago. The clay occurs alongside the Great Perran iron lode in the clay slate on the eastern side of the Treamble valley, its analysis (communicated by Mr. Clark) being :—

	Fuller's Earth.	Clay Slate.
	%	%
SiO_2	56·37	55·00
Al_2O_3	24·20	23·08
FeO	0·42	8·16
CaO	0·31	5·36
MgO	0·29	2·52
Na_2O, K_2O	1·38	3·00
TiO_2	trace	
SO_3	trace	
H_2O free	12·4	
H_2O combined	4·58	
	99·94	97·12

The clay has been classified as a fuller's earth of exceptionally good quality. It seems to be connected with the branching of the iron lode at Treamble and with the intersection of the lode by a north and south fault. At the time of the author's visit, however, the deposit was not sufficiently well exposed to show its relations clearly. It is undoubtedly an alteration product of the clay slate, and the comparison of its analysis with that of the clay slate is of interest. This shows that in the change to the fuller's earth the slate has lost FeO, CaO, MgO, and some alkalies, silica, and alumina, giving a gross loss of solid constituents of 14·5%, which seems to indicate that leaching by water or solutions was the cause of the alteration.

THE GOUDREAU GOLD DISCOVERY, ONTARIO

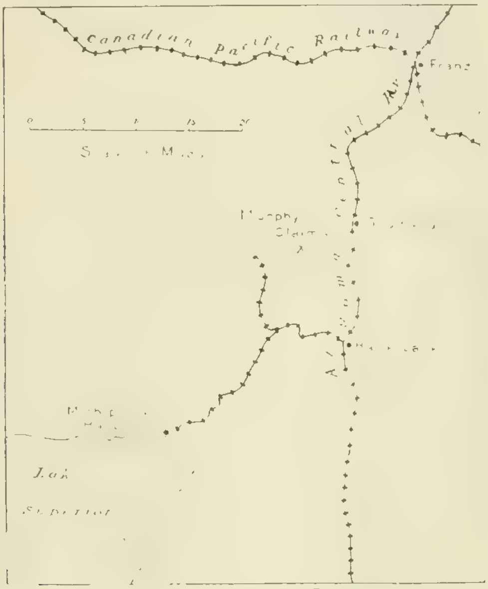
A discovery of gold was made by Thomas Murphy in April last at a point 3½ miles south-west of Goudreau station on the Algoma Central Railway, which is 17 miles south of Franz, a station at the crossing of the Algoma Central and the Canadian Pacific Railway. This region is in the Michipicoten area, bordering on Lake Superior, an area which has hitherto been known chiefly for its iron deposits, although the existence of gold was recorded in W. H. Collins' report for the Geological Survey of Canada issued in 1918. A. G. Burrows, of the Geological Survey, was sent promptly to examine the locale of the new discovery, and his preliminary report has just been received. At the time of his visit C. G. Daimpré was inspecting the Murphy claims, and on the latter's recommendation A. R. Porter, of Toronto, took an option on them. We quote from Mr. Burrows' report herewith.

The area is most conveniently reached from Franz, a station at the crossing of the Canadian Pacific and Algoma Central Railways. Goudreau, which is the nearest railway station to the gold discovery, is 17 miles southward from Franz ; the Murphy claims are about 3½ miles south-west from Goudreau. The camp is reached by a good canoe route, which starts ½ mile south of the station, and follows by way of Jackson, Long, Doherty, Aitken, and Murphy lakes. The longest portage is about 1 mile. The find is located near the north shore of Murphy lake.

The rocks in the area to the south-west of Goudreau are dominantly basic volcanics of Keewatin age. Rocks of this character were observed from Goudreau all along the portage route to Murphy Lake. The ellipsoidal structure, along with amygdules so characteristic of much of the Keewatin, is frequently seen. In places the basic lava contains considerable carbonate and is lighter-coloured than the normal dark-coloured rock. Most of the lavas are altered to schist, which has a general strike nearly east and west. With the lavas there is a small amount of banded iron formation, magnetite and silica. In the vicinity of Goudreau the main iron formation zone is prominent. Two of the large iron pyrites properties, the Goudreau mine of the Nichols Chemical Company and the Rand Consolidated Mines, are near Goudreau ; neither of these is in operation at the present time. With the basic volcanics in the vicinity of Murphy Lake there are several intrusions of quartz-porphyry of quartz-felspar-porphyry ; these acid rocks are generally schistose like the darker lavas. Some of the quartz-porphyry occurs as dykes cross-cutting the strike of the lava flows. A mass of grey granite, gneissic in places, occurs on several claims to the west of the gold discovery. Several narrow dykes of diabase with a north-west strike cut the older formation. One of these is an olivine diabase.

The first discovery of gold was made in a quartz

vein in the south-east part of claim 408, where, for a distance of about 20 ft. along the hanging-wall side of the vein, there are a number of showings of quite coarse gold in the quartz. The quartz vein has been traced by trenching and outcrops for about 800 ft. on claim 408. It strikes approximately N. 30° W., and the dip, where observable, is from 60° to 80° S. It varies in width from 7 in. to 3 ft. Along the quartz vein the wall-rock has been altered in places to a rusty schist containing ankerite and sericite and carrying quartz veinlets together with sulphides at different points. The width of the altered rock appears to vary greatly, but, owing to the small amount of cross-trenching, the width of the possible mineralized wall-rock could not be determined. The hanging-wall contact of the quartz and schist is more definite than the foot-wall. At the location of the gold showings, the vein, including the wall-rock, is about 3 ft. in width, while 15 ft. to the north is



Map showing position of Goudreau.

a subsidiary quartz vein a foot in width, to the north of which is a band of ankerite. Twenty feet to the west this smaller vein is only 3 ft. from the main vein. The quartz vein in places is well mineralized with sulphides, pyrites, copper pyrites, and pyrrhotite ; 150 ft. south-east from the above showing the quartz vein is about 7 in. in width and, in a thin band of sugary quartz and schist on the hanging wall, visible gold was seen.

Work has also been done on claim 407 to the east. At the west line, 200 ft. north of Murphy Lake, a narrow quartz vein about a foot in width has been traced 65 ft. ; it strikes S. 80° E. The wall-rock for a few inches is quite rusty and carries sulphides. Visible gold was observed at two points along the vein. About 200 ft. east from the west line work has been done on a wide ankerite-schist band up to 20 ft. in width, which carries quartz veins roughly parallel with the ankerite band. It has been traced for 170 ft. in a direction S. 70° E. No visible gold was observed in this vein, but at one point an assay of \$6·00 in gold was obtained over a width of 2 ft. 9 in. of quartz and \$4·00 in gold over a width of $5\frac{1}{2}$ ft. of the schist and carbonate, carrying quartz, lying to the north. Owing to the highly altered character of the schist by oxidation, the latter assay is only indicative of the presence of gold which may be concentrated. The quartz vein carries pyrite, copper pyrites, pyrrhotite, and a little zinc-blende. It is possible that this easterly vein is the faulted part of the vein exposed on claim 408. A number of assays of samples obtained at points along the veins showed gold values ranging from a few cents to \$28·00 per ton. In addition, two assays were made of specimens of quartz carrying a high percentage of sulphides from a pit a few feet west of the rich gold showings, which gave \$31·20 and \$48·80 in gold. The property, however, was not in condition for any thorough sampling since few cross trenches had been made exposing the walls of the vein and none below the superficial oxidation. The main vein shows high-grade ore for at least 40 ft. near the discovery, but extensive work will be required to determine the possible ore-shoots along the veins, since large portions of the vein are concealed by drift.

Mr. Burrows also gives an account of gold deposits north-east from Goudreau. Gold has been discovered on a number of claims between Goudreau station and Goden Lake.

The McCarthy-Webb group of claims near Iron Lake has been described by W. H. Collins in his report on the Magpie-Hawk area as already mentioned. Briefly, the rock is a schistose porphyry, which in places is a quartz-porphyry, with a strike N. 84° E. Shear zones occur in the porphyry, and these are indicated by a rusty surface containing vague quartz veinlets, which is in marked contrast to the white porphyry. The rusty streaks are very irregular in length and breadth, being from a few inches to a few feet in width, containing fine-grained iron pyrites. Gold in a very fine state has been found in the rusty zones. In addition, there are widely separated transverse veinlets of quartz carrying much tourmaline, in which coarse gold has been discovered. These veins are more definite than those running with the schist. The property has been sampled several times, particularly in one place for a length of 100 feet, where the rusty condition is most pronounced.

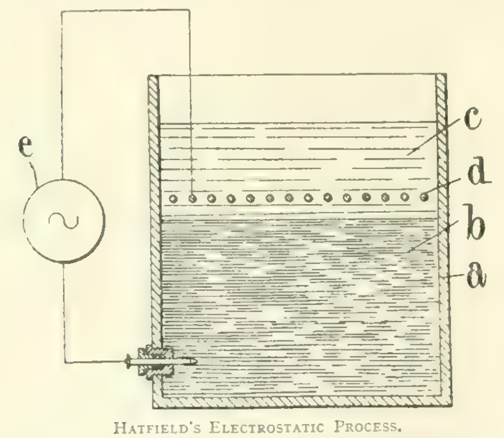
The Morrison claim on the north shore of Goudreau Lake is similar to the McCarthy in structure. However, the rusty zones running with the schist are less pronounced, while there are more of the transverse quartz-tourmaline veins. Visible gold has been found in a number of the narrow veins which are parallel to the schist and also in the transverse veins.

The Cline claims about $1\frac{1}{2}$ miles north-east of Pine Lake were also visited. Visible gold was seen on two of the claims. The rocks are Keewatin schist in which narrow quartz veins have been formed. A shaft was sunk 25 ft. in a quartz vein from $1\frac{1}{2}$ in. to 6 in. in width, in which there is a high percentage of sulphides and visible gold. The extension of the vein to the west, where it was cut by a diabase dyke, has not been found. On another claim there is one narrow rich quartz vein about 5 in. wide in which gold has been found over a length of 20 ft. A second vein from 8 in. to 3 ft. wide occurs on the claim. It consists of quartz and schist on which a 5 ft. pit has been sunk. Material from this vein showed much gold on panning. Owing to the heavy drift covering it

[illegible] the vein [illegible] distance. Some [illegible] were also observed on another [illegible] trench the rusty zone is 15 ft. in width, which [illegible] rapidly to the west. Some visible gold is reported near the north wall. [illegible] work has not been done on any of these claims to determine their value.

Tin Concentration.—British Patents 3,809 and 31,212 of 1920, combined as No. 165,892, describe the invention of H. S. Hatfield for electrostatically separating materials when suspended in liquid mediums. This process has been mentioned in the reports of the Department for Scientific and Industrial Research as applied to the treatment of slime tin, but details of its nature have not hitherto been published. The specification is a long one, and we merely give brief extracts.

According to this invention the powder whose constituents are to be separated one from another is suspended in a liquid the dielectric capacity of which lies between that of the constituents of the said powder. Electrodes in the liquid are connected to an electric supply of considerable potential, preferably alternating; an electrostatic field between the electrodes is thereby produced. Those suspended particles of greater dielectric



HATFIELD'S ELECTROSTATIC PROCESS.

constant than the liquid will then be found to move so as to place themselves along the shortest lines between the electrodes; that is, in the strongest part of the electrostatic field. On the other hand, those particles of less dielectric capacity than the liquid will move out of the electrostatic field between the electrodes. As an example of the separations to which this invention may be applied, the cassiterite in tin ore when suspended in aniline is strongly attracted, while the gangue is not affected. The conductors used may be 0·25 to 1 millimetre apart, and be charged with alternating current of 200 volts. For the separation of cassiterite, and for separation generally, a mixture of nitrobenzene and paraffin oil, which may be adjusted to any desired dielectric constant between 2 and 36, is very useful. With fine suspensions it is necessary sometimes to add an agent which produces deflocculation of the suspension. In carrying the invention into effect in one form as shown in the figure, a vessel *a* is provided containing in its lower part a quantity of water, acid, alkali, or salt solution, or other electrically conducting liquid *b*. Upon this liquid floats another liquid *c* which is that used as the medium of suspension and chosen so as to have a dielectric constant intermediate between those of the particles which are to be separated from one another. In this liquid *c*, and as close as practicable to the boundary of the two liquids, is a perforated electrode *d* connected to one of the poles of an alternating electric supply *e* the other pole of which is led to the electrically conducting fluid in the bottom of the vessel *a*. The solid to be separated is then fed either dry or mixed with a little of the suspension medium into the top of the vessel. It then passes through the perforated electrode *d* and that part of it having a dielectric constant greater than that of the suspension medium comes to rest upon the boundary between the two liquids, while that part of it having a dielectric constant less than that of the suspension medium is immediately forced through the boundary between the two liquids into the lower liquid *b*. Pure capillary forces act upon the solid at the boundary between the two liquids, which either oppose or assist it to pass into the lower liquid *b*, and the success of this method in any given case will therefore depend to some extent upon these forces, and can only be determined by trial. It is found that if amyl alcohol be used for the liquid *c*, and water for the liquid *b*, cassiterite may be separated from gangue, the gangue passing into the water and the cassiterite remaining behind.

Geological Investigations in Rhodesia.—In the Report of the Rhodesian Geological Survey for 1921, H. B. Maufe, the director, gives an account of investigations in the Lomagundi district. He made three traverses into the outlying districts, one of which included a visit to the recently opened mica field. The number of mica deposits and quality of the mica (muscovite) are favourable to the establishment of a mica-mining industry. On this and on another traverse westwards into the Sebungwe district the beds of the Lomagundi system were shown to have a far wider extension than was previously known, and some observations were made on the varying degree of metamorphism of the beds. In this connexion it was pointed out that if the graphitic slates of the Lomagundi system were found to extend into the areas of higher crystallization, it was probable that workable deposits of flake graphite might be found. Since then some very promising flake graphite has been discovered. Among the minerals identified on the mica field is beryl, often in greenish and bluish green tints, which render it probable that aquamarine of gem quality may be found. Other minerals discovered in place on the mica field comprise a few known previously in the Somabula diamondiferous gravels and include the indicator staurolite. The source of these minerals had been a puzzle hitherto.

A third traverse included an examination of the chrome deposits in the Umvukwe hills. The chrome iron ore occurs in seams generally less than one foot thick in the central portion of the Great Dyke. The occurrence of the chrome ore has been aptly compared by A. H. Ackerman to that of a series of coal seams lying one above the other in a basin. The seams dip towards the median line of the dyke at moderate angles, which diminish towards the centre, and there is good reason for believing that the seams extend across from the outcrop on one side to that on the other. The country rock of the seams is usually an enstatite rock partially or wholly altered to serpentine, but on some claims a chromite

seam has a floor of enstatite rock and a roof of serpentine, which appears to be derived either from a dunite or a saxonite. The synclinal structure of the dyke is similar to that already described in other portions, notably by Dr. Wagner in the Belingwe district. The origin of the structure, formerly a purely scientific question, has now become of importance to the chrome miner, and will require elucidation. The occurrence of the chrome iron ore in the Great Dyke is thus quite different from that of the chrome in the well-known deposits at Selukwe. The chrome iron ore in the Great Dyke can, it appears, be picked clean to assay over 50% chromic oxide, and the resources of the Great Dyke in this mineral must amount to many millions of tons.

The chrysotile asbestos now being worked in the Great Dyke is situated near the western edge of the dyke, where the northern continuation of the dyke offsets to the east nearly a mile. The offset appears to be due not to a fault, but to the presence of a large quartz reef in the granite country rock. That the line is one of weakness is shown by the presence of a later dolerite penetrating the Great Dyke close to the line of the offset. The asbestos seams are vertical, of a high average width, and trend in a general east and west direction, being spaced irregularly through the country rock as in the older asbestos deposits. The country rock is serpentine derived so far as could be ascertained by eye partly from an enstatite rock and partly from a saxonite. It is not yet generally realized that the chrome and asbestos deposits occurring in the Great Dyke are very much younger in geological age than the Selukwe chrome, and the Mashaba and Shabani asbestos deposits.

Distribution of Gold in Banket. — At the June meeting of the Chemical, Metallurgical, and Mining Society of South Africa, the new President, F. Wartenweiler, presented a paper on the distribution of gold in banket ore. The constituents of the banket and of the associated quartzite, shale, and dyke rocks, which constitute the ore treated, have been described by a number of investigators; the most familiar description is perhaps that by R. Young, in the book entitled *The Banket*. Both A. F. Crosse and W. A. Caldecott dealt with the constituents of the milled ore many years ago (see *Journal of Chem. Met. and Mng. Soc. of S.A.*, vol. iv, 1903–04, pp. 104 and 110; and *Transactions of Inst. of Mining and Metallurgy*, vol. xiv, 1904–05, The Finer Crushing of Banket Ore, by W. A. Caldecott). Lack of detailed information and the necessity for knowledge on the subject being brought abreast of current practice led to an investigation, the main features of which are given herewith. It was begun several years ago at the Rand Mines laboratory, with the primary object of ascertaining the gold distribution in the ore constituents of the products into which the comminuted ore is classified after amalgamation. Since then the information gained by the method, when applied on samples from different mines, has been found to be of considerable use in controlling reduction works operations. For the purpose in view, it was thought that if a clean separation were made between the pyritic and the gangue portions and their relative gold value determined, the information sought would be acquired. After preliminaries with Sonstadt solution and with flotation, the latter method was decided on as preferable. Tests were begun, using a motor-operated laboratory flotation machine, supplemented by panning of the tailing to separate any coarse pyrite and gold which had not been lifted with the froth. All samples for flotation were ground to pass a 150 mesh linear screen. Various flotation oils were given a trial, the combination finally adopted as the most effective being wood tar oil and turpentine, in a circuit acidified with sulphuric acid. It was found necessary to vary the amount of acid with the class of product treated. A final washing effect in respect to pyrite was secured by the addition of a fractional quantity of wood tar oil toward the end of the flotation agitation. The separation of the pyritic portion was, by observation, clean, this being confirmed by sulphur determination in the tailing, which gave such low sulphur content in terms of pyrite as 0·16% FeS_2 and 0·08% FeS_2. As free gold, not encased, will float in the frothing process, the pyrite, unless otherwise noted, also includes this floated gold. Its incidence was ascertained in several tests. No distinction was made between the argillaceous and the siliceous portion of the gangue. It is known that the truly argillaceous portion is small at the mines of the central district, but is increased at the extreme eastern mines by the inclusion of much shale.

The first data (series *A* and *B*) were derived from tests on samples from the Ferreira Deep reduction plant. These tests were carried out in two series, one in which the agitation and frothing was continued to an extreme extent with the object of ensuring a clean pyrite-free tailing, and the other in which flotation was carried on only to the limit of the clean mineral froth stage, the object being to obtain a clean gangue-free pyrite. The results are given in tabular form by the author, and from them it is seen that the argillaceous and siliceous portion of the slime residue contains the greater part of the gold (60·1%), while the gold in the cyanide pulp is found to the extent of 87·5% in the pyrite portion. In Series *B* the percentage of pyrite by weight, separated by the flotation method, plus panning, corresponds closely with the FeS_2 calculated from sulphur determinations. From a study of this record it is evident that the gold in the pyrite portion of the slime charge dissolves readily in cyanide solution.

Further tests (Series *C*) were conducted on a sample of cyanide pulp, and on a sample of sand charge, and the corresponding residue from the Village Deep plant. The results showed that the gold in the cyanide pulp is distributed 37·5%, 51·4%, and 11·1% respectively, as free gold, in pyrite, and in gangue. When investigating the sand charge and residue, gold encased in the siliceous matrix was determined by the aqua regia method. It does not appear to play much of a part in the residue. If the seal of accuracy be attached to this method of determination, one would accept as established that the cyanide solution penetrates the ore particles and dissolves encased gold. The amount of gold amalgamable in cyanide pulp and in the sand charge, 37·5% and 19·4% respectively, varies with the grinding. It is a revelation, and confirms the general tendency in practice to throw more responsibility for gold recovery on the cyanide section of the plant and less on amalgamation. In considering the distribution of free gold, pyrite, and gangue, it is observed that the first two comprise 90·3% of all the gold in the charge.

A comprehensive series of tests [illegible] were carried out on a City Deep sand charge and the corresponding residue. Free gold was not determined in this series, and is, therefore, included in the pyrite value. Under pyrite content the percentage of gold content is found to increase considerably in the gangue portion of the residue, evidently due to encased gold. Grading analysis discloses the increase in gold percentage content in the coarser gradings, comparing the charge with the residue. The large amount of pyrite by weight and the importance of gold content in the minus 200 mesh grading of the charge is significant, especially when viewed in the light of improvement to extraction on this fine pyrite. All the information in the author's tables under "distribution of gold extraction" and "extraction on pyritic portion" points to the great importance of grinding the maximum amount of pyrite and gold as fine as possible to pass the 200 mesh at least, in order to obtain the highest extraction. Although this has been accepted as an axiom by many workers in this field, it is the aim of this paper to so illustrate and visualize it that it will become forcible to all those interested. From a practical metallurgical standpoint this investigation points to this one significant fact of the need for comminution of the pyrite.

The importance of careful classification and tube-milling follows. If the classifiers do not return the plus 200 mesh pyrite and free gold to the tube-mills for further grinding, then the plant is indeed handicapped. On the ores of the extreme eastern district the application of this maxim is of the greatest importance.

Mining Efficiency.—The question of improving the standard of efficiency and introducing methods for securing economy of working is prominently before the whole mining community in the Transvaal at present, the universal feeling being that something must be done to prevent the untimely closing of most of the low-grade mines. The general question is in the main political, and secondarily it centres round the rule of the men's unions. But apart from these considerations there are many points of detail that can be discussed by the managers and taken into account by both white and black labour. The *South African Mining and Engineering Journal* recently offered a prize for the best essay on "How to Reduce Working Costs and Improve Efficiency in and on the Mines of the Witwatersrand." The prize has been awarded to John Moore, of the Crown Mines. The essay is brief but full of good sense, and we reproduce it here. We would mention also that a paper has been read before the South African Institution of Engineers by F. C. W. Ingle covering the same subject. Copies have not yet arrived in this country, so publication of extracts must be postponed until a later issue.

We quote Mr. Moore in full as follows :—

There is no one thing that will cut the cost of production sufficiently for the low-grade mines to resume work at once. However, a lot of small reductions will cut the costs of the mines at present working and the mines now closed down will be able to resume work, slowly at first, and later on to open up on their former scale.

Firstly, considering surface conditions :—

(1) There is an immense amount of scrap iron and steel that could be remelted to produce pig iron, either for mine consumption or for sale. One blast-furnace for the group would probably be sufficient. That it is possible for a group to make all their own castings, including special alloys for stamp shoes, etc., has been proved by the Calumet and Hecla.

(2) Overlapping authority and petty foremen must be got rid of.

(3) There are mines to-day with a comparatively small tonnage with surface costs of 4s. per ton. Others with large tonnage and surface costs of 7s. per ton. This disparity of costs is startling.

Secondly, underground :—

(1) The repair of worn tools should be undertaken to a greater extent than is at present practised. Shovels, for instance, could have the blades patched when worn, and broken handles replaced by ¾ in. or 1 in. pipe. One end of the pipe can be split and a rivet put in to form the usual D grip. For actual shovelling these are not as good as a new shovel, but for the scraping that is usually done they are just as good. Pipes to be cut and threaded and old taps and valves to be brought to surface, cleaned up, and repaired. New issue should be given only in special cases unless old gear is turned in with the order for new.

(2) Axes and saws, etc., should be exchanged for sharp ones as soon as dulled. This should be done at an underground store, as the delay is often several days before tools left on a station are brought to surface. In the meantime they are rusting and there is a chance of them getting lost. One saw at the present price would pay for a boy two hours per day for a month, to say nothing of the inconvenience caused.

(3) Timber is one of the heaviest costs, especially on the Central Rand. This may be cut down, especially in low slopes, in hammer and reclamation work, by the use of old heavy-section rails in place of sticks as foundations for waste packs. They must be well hitched into the foot and have head boards. A platelayer can cut them to the timberman's measurements in a very few minutes.

(4) Instead of the universal lagging, old pipes may be used across the rails in place of a backwall.

(5) When travelling ways must be kept open, especially when the ground is very heavy and the height not more than 6 ft., waste packs may be built as follows : A layer of stones carefully packed about one foot thick, then across this old hauling rope unravelled and the strands cut to such a length that they reach twice across the pack with the ends away from the travelling way. These are placed about one foot apart. Another layer of stone, and this time the strands are laid at right angles to the first. These so bind the pack that it will crush to about two-thirds of its original height without bulging. The ordinary pack will crush very little before bulging.

(6) There are many other ways of saving timber, reclaiming some distance from the faces, etc., that are used everywhere, but the two above are not in common use on the Rand.

(7) At present the native labourer spends on an average of two hours per day in a prescribed waiting place till his boss takes him to his working place. In bad ground it is admitted that a white man should always be present, but in the average stope a timberman or trammer could inspect the working place, start the boys, and then go to the more dangerous places where constant supervision was necessary. These men would go down, say, two hours before the ordinary shift. This would allow about two hours extra working time for the

natives at no additional cost to the mine. It would also solve the native labour shortage. In the case of hammer and machine boys, they would not be allowed to drill, but could lash benches, set up, and generally get ready for the day's work. [These conditions have since been improved.—EDITOR.]

(8) The items discussed above all influence the cost of production, but the most important of all is to give the day's pay man an added incentive to put his head and back into the work. This alone will restart every low-grade mine on the Rand. A man working for himself will do twice as much as a man on day's pay, and do it easier. To cut the day's pay man's wage, no matter what the excuse, most certainly will not do it, and, on the other hand, a glance over the cost sheets of American and Canadian mines will show that, conditions being equal, the mines that pay the best wages have the lowest labour costs per ton.

The following bonus scheme is working successfully in a number of places. The usual guarantee or day's pay is given, and a bonus is given for points above a certain set standard, and debits for below that standard. The standard would be set for each mine captain's section, or, if possible to keep the tonnage separate, for each shift-boss's section, and would be based upon tonnage (skip or haulage), grade (sample office), native and white efficiency. The tonnage and native and white efficiencies could be taken as an average per day for, say, the three months previous to the adoption of the scheme. The unit of tonnage might be taken as 1,000 tons, the efficiency unit as one ton, and the grade unit as one dwt. This would require some slight modification in exceptional cases, such as in a section which was just being opened up or where several stopes were stopped simultaneously. This only applies to the day's pay man; the contractor would not benefit by it in any way. The day's pay man would get his bonus cheque some time after the first of the month. By making every man virtually a contractor his best work would be secured and no man would see another loaf if his own bonus cheque was imperilled, no matter what the union said about it.

(9) Another change that would make a difference on the right side is to give the shift-boss his old control over his men. The Chamber of Mines did a bad thing when they took the power out of the shift-boss's hands. Admittedly it was abused at times, but if members of the Chamber had to go underground as shift-bosses to-day and keep up the standard they expect shift-bosses to keep up, there would be a change before night to the old way. Increase or decrease of working costs and native and white efficiencies are the true indications of success or otherwise, and a glance, especially at the latter, will show it has not been a success.

Operation of Mine Fans in Combination.—At a meeting of the Mining Institute of Scotland held last month, a paper by David Penman was presented, dealing with a new method of measuring ventilation resistances, with special reference to the operation of mine fans in combination. His general conclusions with regard to fans in combination were as follows: (1) The advantage to be gained by two or more fans in series or in parallel depends chiefly on the relation existing between the resistance of the fans and that of the mine. (2) Unless the resistance of the fan is small compared with that of the mine, the operation of two fans in series will result in a greatly lowered efficiency. (3) Unless the resistance of the fan is at least one-third of the resistance of the mine, the advantage of running two fans in parallel is small. (4) If the resistance of the fan is small compared with that of the mine, not only will the increase of quantity by parallel operation be small, but a slight reduction or increase in the speed of one of the fans over the other will result in the air being reversed in that fan which runs at the slower speed. (5) If increase of quantity is the sole desideratum, better results will in most cases be obtained by combining the fans in series than by running them in parallel. (6) The increase of quantity obtained by running two similar fans in series at the same speed at which they would run singly would in most cases be approximately 35%. (7) The increase of quantity obtained by running two similar fans in parallel would range from 5 to 15% in the majority of mines in Great Britain. (8) The satisfactory running of two fans in parallel can best be accomplished through the medium of synchronous electric motors. (9) If two fans are running in parallel and the speed of one should fall to any extent, the other fan may become dangerously overloaded, unless there is a large margin of power available in the motor or engine driving it.

Moisture in Furnace Blasts. — In the *Engineering and Mining Journal* for August 13, J. H. Gillis gives a record of observations with regard to the effect of moisture in the air delivered as blast in a copper-nickel blast-furnace.

In March, 1920, an exhaust pipe was so placed that the small amount of steam escaping was being drawn into the intake of a certain blast-furnace blower. Some days elapsed before this was corrected, and the incident was soon all but forgotten. Some weeks later, when the author was making investigation as to certain operating conditions, it was noticed that there was a particularly favourable period extending over a few days, with no corresponding favourable conditions to account entirely for it. After eliminating other factors to determine the cause of these conditions, he came to the conclusion that, as it corresponded with the period in which the steam was being drawn into the intake, possibly the extra moisture was the factor sought. The data, however, were not conclusive; they were affected by other conditions and could not be taken as definitely establishing much basis for future investigation. A search of the available literature on the subject, and discussions with the local metallurgists, failed to explain the results observed, and it was October before further experiments could be made. A test was then determined upon, and a ⅜ in. pipe was connected between the air main and a steam pipe carrying 180 lb. of steam with 100° F. of superheat. A decided change in the operation of the furnace resulted, but here, again, the results were confused by other factors. The experiments were continued, and larger quantities of steam were added, but the results after the first few days were negative. The steam would be turned on and gradually increased, with the result that at fir[illegible]
the furnace would speed up, and crusts
accretions would be eliminated, and then [illegible] 260
effects would disappear. No bad e[illegible] 260
observed, however, until sufficient st[illegible] ....
so that the water from the cond[illegible]e 261
blast began to give trouble aro[illegible]
No accurate methods of measuri[illegible] KE 261
were available, but deductions [illegible] crusl[illegible]solidated Main
[illegible]

the temperature of the blast and its moisture capacity. The experiments were eventually discontinued owing to inability to get definite results.

After study of the various operating curves covering the period of the experiments, the author came to the conclusion that he had been using too much steam, and decided to make another trial as soon as a favourable opportunity presented itself. About the end of January, 1921, after two weeks of uniform furnace operation, the steam was again connected, and a very small amount used. The temperature of the air outside ranged between zero and freezing, and the air in the blast main about 70° F. above that. Sufficient steam was added so that the air was just saturated; that is, some condensation showed in the valves and beds of the pipe. Rough calculations indicated that about 300 lb. of steam was used per hour, or 7,200 lb. per day, which at the cost of evaporation (which was high that month), amounted to $7·20 per day for steam. The tabulated results show an increased tonnage of 14·7% for the two days of the test over the average of the five days' previous, and at no time, even with the use of extra coke, had it been possible to make the same record without steam, although in the previous experiments it had been nearly equalled on several occasions. There was no change in any other operating condition during the period and no material change in the weather. The first day's run does not coincide exactly with the period for which steam was on, as the statistical day started at 7.30 a.m. and steam was connected about 9.30 a.m. On the third day the furnace was down a few hours to change the spout, and the author had no opportunity of making further tests. Although the results given show increased capacity only, there are reasons to believe that corresponding savings in operation costs could be made through saving in coke and flux and in smooth operation.

FURNACE PERFORMANCE BEFORE AND DURING THE TEST

	Ore	Flux	Coke	Per cent of Coke on Ore	Per cent of Coke on Charge
Five days previous to test	811·20	[illegible]	119·00	14·7	10·4
	811·20	[illegible]	116·00	14·4	10·2
	[illegible]	[illegible]	107·30	14·0	10·0
	712·85	269·00	99·85	14·0	10·0
	713·60	306·70	116·70	14·3	10·4
First day of test ..	896·40	315·40	125·44	14·0	10·4
Second day of test	899·10	316·35	127·45	14·2	10·5

The furnace was 50 in. by 30 ft., of ordinary water-jacketed type, and was smelting raw pyrrhotite ore with converter slag as flux. The results obtained indicate an advantage to be gained by the use of steam in smelting sulphide ores, and tests could be conducted at little expense in almost any plant, which would tend to increase the available information on the subject and perhaps make a material saving on operating costs. The author is desirous that other metallurgists should contribute to this discussion.

SHORT NOTICES

WOL- **centration Problems.**—At the meeting of to resul- and Institute of Mining, Civil, and up on the Engineers held at Sheffield on Firstly, co- nley Nettleton read a paper entitled (1) There is ent of Minerals, indicating a new and steel that ating minerals. We intend to iron, either for m vith some comment, in the next blast-furnace for

Coal Mining by Steam Shovel.—At the meeting of the Institution of Mining Engineers held on September 14, George Sheppard read a paper on coal mining by steam shovel in Alberta.

Grinding Problems.—In *Chemical and Metallurgical Engineering* for August 10, H. W. Hardinge reviews the modern problems of grinding, wet and dry, to various stages of comminution.

Flotation.—The *Mining and Scientific Press* for July 30 gives particulars of the Lockenbach flotation process, in which a frothing and selecting agent consisting of pine-pitch in an alkaline solution is employed.

Nodulizing.—In the *Engineering and Mining Journal* for August 13, C. L. Colbert describes the latest nodulizing practice for flue dust and fine concentrates at the United States Metal Refining Co.'s works at Chrome, New Jersey.

Chloride Volatilization.—The *Mining and Scientific Press* for July 30 publishes an account by T. Varley and C. C. Stevenson of investigations into the chloride volatilization process. Articles on this subject by Ben Howe and S. Croasdale were published in the MAGAZINE for December, 1913, and March, 1914, respectively.

Geological Sections.—At the meeting of the Institution of Mining Engineers held on September 14, Harry Roscoe read a paper entitled: Suggestions for the Standardization of Geological Sections of Strata proved by Bore-holes, Shafts, etc.

Spitsbergen.—The *Geographical Journal* for July contains an illustrated paper by J. M. Wordie on present-day conditions in Spitsbergen. The author is one of the geologists connected with the exploration of Spitsbergen.

Engels Copper Mine.—In the *Mining and Scientific Press* for July 30, A. B. Parsons commences an article on the Engels copper mine, California.

Graphite.—In the *Engineering and Mining Journal* for August 6, B. L. Miller reviews the graphite industry of the United States and Canada, giving an account of modern methods of concentration.

Copper Deposits in Arizona.—In the *Engineering and Mining Journal* for August 13, G. J. Mitchell describes replacement copper deposits in the Warren district, Bisbee, Arizona.

Pulverized Coal.—The *Engineer* for August 19 contains a description of the Bettington boiler, using pulverized coal as fuel, made by the Fraser and Chalmers Engineering Works, Erith.

Oil and Pulverized Coal.—In *Chemical and Metallurgical Engineering* for August 3, G. S. Perrott and S. P. Kinney describe the Trent process, according to which powdered coal in water is treated with comparatively large volumes of oil, the pure coal and the oil forming a plastic fuel, while the ash remains in the water.

RECENT PATENTS PUBLISHED

☞ *A copy of the specification of any of the patents mentioned in this column can be obtained by sending 1s. to the Patent Office, Southampton Buildings, Chancery Lane, London, W.C. 2, with a note of the number and year of the patent.*

5,224 of 1920 (139,216). J. E. KENNEDY, New York. Improvements in gyratory crushers.

7,848 of 1919 (165,822). W. M. MORDEY, London. Electro-magnetic separators for the treatment of minerals, consisting of inclined launders with an alternate current multiphase magnet underneath which diverts the magnetic material to one side of the launders.

11,185 of 1919 (126,626). P. DESACHY, Paris.

Improved apparatus for making lithopone, that is, a mixture of barium sulphate and zinc sulphide.

17,745 of 1919 (165,465). F. CALVERT, Manchester. Improved practice in adding fluor-spar in steel purification.

1,375 of 1920 (166,292). ROPEWAYS, LTD., and E. ROE, London. Improved raising and lowering tackle for aerial ropeways.

5,561 and 35,632 of 1920 (166,929). J. J. COLLINS, Southport. In the treatment of zinc-lead and like sulphide ores and concentrates for the separation of the zinc from the lead, subjecting the crushed ore or concentrate while in a solution of a lower chloride of a metal to the action of gaseous chlorine, whereby the lead is converted from the sulphide to the chloride which precipitates on cooling, while the zinc sulphide remains substantially unattacked, drawing off the solution of the lower chloride of a metal from the zinc sulphide, lead chloride, and sulphur, and dissolving the lead chloride in a hot saturated solution of sodium chloride, leaving the zinc sulphide and sulphur.

9,149 of 1920 (141,044). AMALGAMATED ZINC (DE BAVAY'S), LTD., Melbourne. Improvements in patent 135,968, dealing with the separation of mixed chlorides by brine solution for the recovery of lead and silver from complex ores.

9,445 of 1920 (141,688). ELECTROLYTIC ZINC CO. OF AUSTRALASIA, LTD., Melbourne. Method of recovering cadmium in the course of the electrolytic process for producing zinc.

9,846 of 1920 (166,647). A. M. MACKILLIGIN, London. A machine consisting of a number of jumpers for drilling holes in a row and operated in much the same manner as stamps.

10,959 of 1920 (166,695). J. J. COLLINS, Southport. A process of purifying tin, consisting in producing pure stannous chloride from the impure metal by the action of stannic chloride on the latter in the presence of an excess of tin, dehydrating, fusing, and electrolysing the stannous chloride, whereby pure metallic tin and stannic chloride are formed.

11,116 of 1920 (142,122). H. MEHNER, Charlottenburg. A process for the manufacture of cyanogen by reaction between carbon, nitrogen, and the vapour of an alkali metal, in which the free alkali metal is introduced in the reaction space, together with a combined alkali metal of such nature that no reaction between the free and the combined alkali metal can occur during the process.

13,775 of 1920 (166,409). C. LANGER, Woolhampton. Method of separating metals such as copper and nickel electrolytically and depositing them simultaneously by employing two electric currents of different potentials.

14,625 of 1920 (143,920). ELEKTRO-OSMOSE GRAF SCHWERIN GESELLSCHAFT, Berlin. A process for concentrating by the flotation method finely comminuted ores containing electro-positive and electro-negative particles, wherein there is caused to act on the finely comminuted ore in aqueous suspension, for the purpose of separating one set of particles from the mixture, an electrolyte having an electric charge of the same character as that of the set of particles to be separated, and wherein for the simultaneous or subsequent flotation concentration there is used as floating agent a substance which does not prevent or destroy the sol-condition.

15,901 of 1920 (167,048). H. WALKER, Christchurch, New Zealand. In order to provide oxygen and moisture at the same time as firing shots in mines, using a cartridge containing permanganate of potash, chlorate of potash, and gum arabic, in association with the blasting cartridge.

16,701 of 1920 (165,655). SKINNINGROVE IRON CO., LTD., and T. R. SMITH, Saltburn, Yorkshire. A negative electrode for use in an electrostatic dust-depositing plant, consisting of chain-mail or the like supported at the top on a stationary bar and with a heavy bar attached to the bottom edge thereof, in combination with mechanism for lifting the heavy bar at intervals and allowing it to fall in order to impart a jerking action to the electrode.

17,062 of 1920 (146,133). SOCIÉTÉ ELECTRO-METALLURGIQUE FRANÇAISE, Paris. Method of preparing aluminate of lime for the manufacture of pure alumina, which consists in dividing the operation into two phases and making use of two apparatus ; in the first phase crushed bauxite mixed with lime is heated in a rotary furnace constituting the first apparatus, which is heated by waste heat from the second apparatus, and in the second phase the mixture is discharged from the rotary furnace into the second apparatus which is a furnace heated and arranged for effecting the fusion of the mixture, which on being discharged may be cooled and granulated in water.

19,014 of 1920 (161,104). F. MILLIKEN, Lawrence, New York. An alloy capable of resisting high temperatures consisting of chromium, copper, nickel, manganese, and 16 to 20% iron.

20,253 of 1920 (153,560). S. STEINMETZ, Berlin. Improvement in disc crushers.

23,238 of 1920 (161,491). DWIGHT & LLOYD METALLURGICAL COMPANY, New York. Improvement in the inventors' apparatus for continuous ore-sintering.

32,585 of 1920 (161,130). SVENSKA DIAMANTBERG-BORRNUNGS AKTIEBOLAGET, Stockholm. In ascertaining the inclination of bore-holes, the employment of a solution from which a etallic deposit can be precipitated electrolytically by making connexion when desired, instead of the etching solution hitherto employed.

32,715 of 1920 (165,708). T. G. NYBORG, Hexham, and M. F. HIGGINS, Sheffield. Method of fixing the tube bringing clearing fluid to the points of percussive drills.

35,794 of 1920 (166,490). S. DAWSON WARE, London. A jig having one or more power-moved screens or screen-trays covering practically the whole area of the tank or hutch, suspended from an overhead framework, vibrated or reciprocated both vertically and horizontally by two independent positive quick-return motions.

36,492 of 1920 (164,681). E. CUDNEY, Stege, California. Improved electric blasting fuse.

801 of 1921 (156,739). F. KRUPP, Magdeburg-Buckau. Improved form of plates used in filter-presses.

4,518 of 1921 (165,719). G. H. T. RAYNER and P. RAYNER, Sheffield. Valve apparatus for rock-drills and similar tools, comprising a three-collar valve, said collars being of equal diameters, characterized in that the central collar controls th main fluid supply and diverts it alterr 260
each side of the piston, the piston op
closing valve-throwing ports from the c 260
covering and uncovering exhaust por
cylinder to the atmosphere during the 261
return strokes. 261

6,987 of 1921 (160,464). J. E. KE
York. Improvements in gyratory crusl solidated Main
Modderfontein

NEW BOOKS, PAMPHLETS, Etc.

Copies of the books, etc., mentioned below can be obtained through the Technical Bookshop of *The Mining Magazine*, 724 Salisbury House, London Wall, E.C. 2.

Quin's Metal Trades Directory of the United Kingdom, 1921. Cloth, octavo, 300 pages. Price 10s. 6d. net. London: The Metal Information Bureau, Ltd., 7, East India Avenue, E.C. 3. This is the first issue of a book which gives classified information relating to the non-ferrous metals business of this country.

South African Engineers Electrical and Allied Trades Directory, 1921–1922. Cloth, octavo, 490 pages. Price 30s. net. Johannesburg: The *South African Mining and Engineering Journal*, London Office: 82–5, Fleet Street, E.C. 4.

First Aid and Rescue Work in Mining. By Dr. L. G. Irvine. Flexible covers, pocket size, 370 pages, illustrated. Price 8s. 6d. net. Johannesburg: The South African Red Cross Society. London: The Mining Magazine.

Talc; Fluor-Spar.—Published by the Imperial Mineral Resources Bureau. Price 9d. each.

Income Tax Guide, 1921.—By H. W. Palmer. Price 1s. net. London: *The Financial Times*.

Mineral Industry of the British Empire and Foreign Countries.—Statistical Summary of Production, Exports, and Imports, 1913 to 1920. Published by the Imperial Mineral Resources Bureau. Price 3s. net.

Concentration by Flotation.—By T. A. Rickard. Cloth, octavo, 690 pages, illustrated. Price 42s. net. New York: John Wiley & Sons; London: Chapman & Hall, Ltd. This book is a compilation of articles appearing in the *Mining and Scientific Press* during the years 1915 to 1920.

Mining Law of West Africa.—Price 15s. net. Published by the Imperial Mineral Resources Bureau.

Sir John Cass Technical Institute.—Syllabus of Classes for Session 1921–2. Issued by the Institute, Jewry Street, Aldgate, London, E.C. 3.

Lead, Zinc, Copper, and Nickel Ores of Scotland. By G. V. Wilson, with contributions by Dr. J. S. Flett. Paper boards, octavo, 160 pages, illustrated. Price 7s. 6d. net. Published by the Geological Survey of Scotland. Reference is made to this book in an editorial in this issue on copper in the Shetland Isles.

The Mutue Fides-Stavoren Tinfields. By Dr. P. A. Wagner. Paper covers, octavo, 200 pages, illustrated. Price 7s. 6d. net. Memoir No. 16 of the Geological Survey of the Union of South Africa.

The Mining Geology of Kookynie, Niagara, and Tampa, in the North Coolgardie Goldfield. By J. T. Jutson. Paper covers, octavo, 100 pages, illustrated. Bulletin No. 78 of the Geological Survey of West Australia.

COMPANY REPORTS

Leeuwpoort Tin Mines.—This company is controlled by the South African Townships Mining and Finance Corporation, and has worked tin mines wo… Waterberg district of the Transvaal since to resum… Irvine Jameson is the manager. The up on th… 1920 shows that 61,982 tons of ore was Firstly, c… that, after the removal of waste, 55,335 (1) There … t to the stamps. The yield of tin and steel tha… was 985 tons, averaging 62% metallic iron, either fce of concentrate brought an income blast-furnace The mining costs were £88,358, … ation charges £23,484. The allowance for development and depreciation written off was £14,990, and the taxes, etc., £6,021. The shareholders received £41,250, being at the rate of 15%. The ore reserve is calculated at 64,488 tons, averaging 2·4% metallic tin, figures not much different from those the year before.

Ropp Tin.—This is the largest producer of tin concentrate on the Bauchi plateau, Nigeria. Edmund Davis is chairman of the company, and the Consolidated Gold Fields of South Africa are the consulting and superintending engineers. The report for 1920 shows that the output of concentrate was 1,017 tons, of which 619 tons was obtained by dredging, 162 tons by ground sluicing, 150 tons by tributing, and 86 tons from other sources. The proceeds from concentrates sold were £52,900, and there are credits of £59,064 for concentrates on hand and in transit. There was a loss on the year's work of £7,595, this position being entirely due to the fall in the price of tin. The proved ground is estimated to contain 10,006 tons of cassiterite. No new ground has been tested during the year. The output during the first half of the current year was 561 tons.

Waihi Grand Junction.—This company has worked a gold mine in the north island of New Zealand, adjoining the Waihi mine, since 1895. Dividends were paid from 1910 to 1918. The report for 1920 shows that 57,450 tons of ore was raised and treated, yielding gold and silver valued at £109,506. The working cost was £130,463, and provision for income tax £4,238. There was in addition an income of £8,005, arising chiefly from interest on investments. The result of the year's work was a loss of £21,016, which, added to the adverse balance of £10,550 brought in from the previous year, makes a total debit balance of £31,566. The ore reserve is estimated at 120,500 tons, as compared with 90,450 tons the year before, but assay-values are not given. The directors do not now publish the mine manager's report, nor do they give details of gold and silver production and the premium received on the gold sold.

Broken Hill Block 14.—The report of this company now issued covers the half-year ended March 31. The mine was reopened at the conclusion of the strike on November 22, but operations were suspended again at the end of December, owing to the unsatisfactory condition of the metal markets. During the short time the mine was being worked 405 tons of carbonate ore, averaging 24·3% lead and 13·8 oz. silver per ton, was mined and delivered to the Associated Smelters at Port Pirie, and 1,201 tons of sulphide ore was raised and sent to the Block 10 joint plant. The accounts show a loss for the half-year of £17,671.

Broken Hill Block 10.—The report now issued covers the half-year ended March 31. The long strike terminated on November 10, and from that date until the end of December some mining was done, while the concentration plant, treating Block 10, Block 14, and Junction ore, ran from November 15 to January 31. The joint treatment of ore from the three mines named included 3,386 tons from Block 10, and 6,234 tons from Block 14 and Junction, making a total of 9,620 tons, averaging 11·5% lead, 9·34% zinc, and 8·89 oz. silver per ton. The lead concentrate won was 1,508 tons, averaging 61·3% lead, 6·5% zinc, and 36·6 oz. silver, and the zinc concentrate 1,718 tons, averaging 45·7% zinc, 7·26% lead, and 13·9 oz. silver. The accounts show a loss for the half-year of £18,800.

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Many minerals are easily mistaken for cassiterite. The author of this article gives a concise statement dealing with the subject, intended for the guidance of workers in the field.

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EDITORIAL

THE great explosion at the Badische Anilin & Soda Fabrik's works at Oppau points to the danger of the explosives containing ammonium nitrate or of the process by which it is made, and the manufacturers of mining explosives will investigate accordingly. The information available at present is, however, not sufficient to warrant any expression of opinion.

ON October 10 a lecture on the geology of petroleum was given by Sir Frederick Black, president of the Institution of Petroleum Technologists, at the Sir John Cass Technical Institute, Jewry Street, Aldgate. This lecture constituted an introduction to the course on petroleum technology which has this year been added to the curriculum of the Institute. We are glad to see the continual expansion of the Sir John Cass Technical Institute. The lectures and instruction are eminently suited to the requirements of men engaged during the day time, and both technical and non-technical men find the courses of study extremely helpful.

ELSEWHERE in this issue we print an article on the "Characteristics of Cassiterite," by Mr. E. H. Davison, lecturer on economic geology and mineralogy in the Camborne School of Mines. This article may appear to some readers to be rather elementary for a paper like THE MINING MAGAZINE. The fact is, however, that many minerals are continually being mistaken for cassiterite, and vice-versa, so that a concise statement giving the characteristics of all these minerals should prove useful in many quarters. The identification of cassiterite is a subject on which much could be written, and we hope some of our readers will send contributions to our pages giving details of their particular experiences in the field.

THE contempt displayed by politicians and the public for scientists and mining men forms the theme for many paragraphs in this issue. One of those to utter a protest against this treatment is Mr. T. G. Trevor, the Inspector of Mines for the Pretoria District, who in the *South African Journal of Industries* for August appeals to the public to put more faith in the value of the services of the scientific man. As this appeal takes the form of an article appearing in a monthly magazine published by authority of the Minister of Mines and Industries, it is clear that the appeal stands a good chance of being read by the politicians.

WE note with pleasure that *Nature* takes up the cudgels on behalf of Sir Thomas Holland, who has been obliged to resign from the Council of the Viceroy of India under circumstances already known to our readers. Lord Reading's assertion that the Minister of Commerce should have been a lawyer instead of a man of science is one of those legal generalities which create so much havoc in the world of common sense, and the men of science resent it in a body. No doubt the dismissal of Sir Thomas Holland will be brought before Parliament in due course, for this degradation of a competent and sympathetic Minister was a most ill-advised action, especially at the present time, when the future of India is in the balance.

MINING engineers found much to interest them at the Shipping, Engineering, and Machinery Exhibition held at Olympia last month, as will be seen from the brief description printed elsewhere in this issue. One of the features of the Exhibition was the holding of special receptions for various classes of engineers, on which occasions lectures were delivered on the subjects of greatest novelty in each particular line. One evening was set apart to the Institution of Mining Engineers and the Institution of Mining and Metallurgy, and the social intercourse and the opportunity for inspecting the exhibits in congenial company were greatly appreciated. A lecture and demonstration was given by Professor Edwin Edser, who explained the principles of froth flotation as applied more especially to the saving of waste coal. When future exhibitions of this class are held we hope to see the makers of machinery used at mines more widely represented. As a matter of fact we believe that at the next exhibition efforts will be made to secure a representative show of modern types of mining machinery of all kinds.

PARTICULARS are to hand of another shaft-sinking record. At the Chief Consolidated mine, in the Tintic district, Utah, the Water Lily vertical shaft was sunk 427½ ft. during the 31 days from July 15 to August 15. The first 367 ft. passed through a porphyry formation, and the last 60 ft. through a moderately hard close-grained limestone. The shaft has three compartments, each measuring 4 ft. 4 in. by 4 ft. 6 in. The surface equipment consists of two small hoists and two air-compressors operated electrically. Hoisting was done through two compartments. Timbering was done as the work proceeded by means of a suspended steel bulkhead hung from each last set, so that drilling and hoisting could be done continuously. The drill employed was the Waugh Clipper, and the average number of holes drilled each round was 23·9. The particulars supplied do not include the depths below surface of the start and finish of this trial. The previous 31 days' record was the 310 ft. sunk at the Crown Mines No. 15 circular shaft in July, 1919. Here the shaft was 21½ ft. in diameter, and the hoisting depth averaged 2,150 ft., while the rock was hard Rand quartzite and the drills employed were Holman sinkers. These shaft-sinking competitions are not official, and there is no handicapping as regards rock, energy of the crew, or capability of the drills employed, so all we can do is to congratulate the respective crews for getting a move on.

British Coal-Mining

There are signs that all sections of the community are now taking a more reasonable attitude with regard to coal-mining, the industry on which the prosperity of this country depends. Both the owners and the workers are listening more readily to the advice of well-informed men of independent position. Perhaps the most notable pronouncements of this sort were made by Sir John Cadman and Dr. J. S. Haldane at the recent meeting of the Institution of Mining Engineers. Sir John, in his presidential address, spoke in frank and unmistakable language of the causes of the present unsatisfactory condition of the industry. He showed that, whereas in 1900 the output of coal was 291 tons per man employed, the figure had fallen to 183 tons in 1920. There are several factors which may have contributed to this fall. The thicker and more accessible seams are gradually being exhausted, and thinner seams and seams at greater distances from the shafts are being worked. Some people also maintain that the mines are overmanned, and that the surplus force does not add to the productive capacity of the collieries. It may be, as Sir John said, that all British industry has been passing through one of those lazy fits that recur from time to time. But all these are held by him as not affording the real reason. In his view over-legislation is the cause which operates the most effectively in restricting output. During the last twenty years coal-mining has been subjected to a degree of political and legislative interference without parallel in any other industry. These enactments have so circumscribed the initiative of both masters and men in matters that might have been much better left to their own discretion, and have so fettered their freedom of action and choice as to stifle their natural spirit of energy and enterprise. The restrictions and regulations were mostly imposed by outside authorities little conversant with the matters in hand, and the legislation has been fussy and ill-conceived; the result of the regulations has been the virtual abolition of personal responsibility and of co-operation between managers and men. In fact, hasty and inappropriate laws have diminished the output, and at the same time have not increased the safety of working. There are really so many regulations that the time of the managers and men is taken up chiefly in following them and signing forms, and personal initiative in mining practice has been stifled. In Sir John's words, what coal-mining in Great Britain most needs is a respite from the well-meant but bungling attentions of Parliament.

In the speeches following the delivery of Sir John Cadman's address, Dr. J. S. Haldane spoke in his capacity as adviser on improvements in underground conditions, and he voiced the general complaint of scientific men that their advice is often ignored, and that if it is accepted it is usually applied by people who have no knowledge of the subject. His contention is that, if certain recommendations of a scientific committee are agreed to, the advice of that committee as to the methods of carrying them out in practice should also be taken. He showed that in many cases scientific recommendations have been quite wrongly applied. Even if the committee particularly requested that no legislation should be under-

taken without further reference to them, the Government officials continue in their usual course. Dr. Haldane instanced cases where his own recommendations had been applied in such a way that little good has ensued; in fact, the regulations founded on them only served to tie the men up in such a way that they did not know which way to move. It is to be hoped that the protests uttered by two such high authorities as Sir John Cadman and Dr. Haldane will have some effect on the Government; they will certainly be accepted by the coal industry and all associated with or dependent on it.

Arizona Copper

For two years or more the directors of the Arizona Copper Company have been in negotiation with the Phelps-Dodge Corporation with a view to the sale of the properties to the latter. After much delay terms have been agreed and placed before shareholders. It may be said at once that the terms have been considered disappointing, and that the shares have suffered considerably on the market accordingly. We believe, however, that this dissatisfaction is not well founded, and that shareholders will eventually find they have a sound and satisfactory investment. Briefly, the purchase price paid by the Corporation is 50,000 shares of $100 each, to rank equally with shares that have received an average return of 18% per annum during the last twelve years. The present issued capital of the Corporation is 450,000 shares of $100 each, so that the Arizona Copper Company will hold just one-tenth of the shares of the Corporation. The issued capital of the Arizona Copper Company is £703,984, of which rather more than half is represented by ordinary shares. During the last dozen years the dividends on the ordinary shares have averaged 50%, but owing to the severe collapse of the copper market no profit was made in 1920, and the mine was closed in May of this year, along with many other American copper mines. At first sight the times may not appear auspicious for a sale of the properties, and that a company which has to find means for financing its present losses and also has a prospect of having to raise further capital for the exploitation of the lower grade ore is not exactly a free agent in the deal. But the Phelps-Dodge Corporation is not an organization that relies on the big stick policy, or holds a pistol to the parties with whom it negotiates; moreover, it does not keep an eye and a half on the Stock Exchange, and only half on its proper business. The Corporation and its predecessor, Phelps, Dodge & Co., have a fine record for technical ability and business probity, and any agreement to which it sets its seal is likely to prove a fair one. Its commanding position in the copper world was largely built up by the late Dr. James Douglas, whose high character was proverbial. The shares are almost entirely held privately by people who value them for the income they yield, and they seldom change hands. Shareholders in the Arizona Copper Company must learn to adopt the same attitude. It is clear, on the other hand, that some means of valuing or selling holdings on this side is desirable, and for this reason the Phelps-Dodge shares will not be distributed among Arizona Copper Company shareholders, but will be held by the latter company, which will thus become a holding instead of an operating company.

The two companies began active work in Arizona at about the same time, the Arizona Copper Company in the Clifton-Morenci district, which was the first copper-mining region to be developed in the South-Western States. The discoveries leading to the commencement of a new industry happened about 1875, but it was not until the early eighties that active work was taken in hand. In those days rich oxidized ores in a limestone gangue were treated, and the smelting experiences on this class of ores formed an interesting incident in the history of the metallurgy of copper. The Corporation began work at Bisbee, and later acquired the Detroit property at Morenci, the Globe and Old Dominion at Globe, the Moctezuma group over the border in Sonora, and the Bunker Hill at Tombstone, while smelting operations have been conducted at Bisbee, Douglas, Globe, and Morenci. The ores treated in the Clifton-Morenci district have gradually become of lower and lower grade, and the methods of mining, concentration, and smelting have had to be continually modified. To the Arizona Copper Company belongs the credit of having first treated the so-called "disseminated" or "porphyry" type of deposit, long before Utah Consolidated and Miami were heard of. The Arizona Copper was also the first company to establish leaching plants for the oxidized ores. It is worthy of record

that a substantial proportion of the ore-minerals now mined are oxidized, consisting of malachite, with smaller amounts of cuprite, chrysocolla, and other compounds, but the chief mineral of the ores is chalcocite. At the present time the Arizona Copper mines and the Detroit mine are showing signs that another entire rearrangement of the mining and concentration methods will have to be undertaken so as to treat the vast reserves of ore of a still lower grade. The capital sum involved will probably come to millions of pounds, and the Corporation is better able to provide the funds. Another point in favour of the Corporation undertaking this work is that if the money were provided in this country a considerable loss would be incurred in sending it to the United States with the dollar exchange in its present position. The Corporation's interests in the Clifton-Morenci district are far from being the most important of its possessions. The Copper Queen and the Moctezuma are big producers of copper, the Tombstone mines yield lead, silver, and gold, and the Corporation also operates coal mines at Stag Canon. The Arizona Copper shareholders may therefore be congratulated on securing a permanent interest in a company which has such a wide ramification of possessions. We cannot do better for a peroration than quote the *Copper Handbook*, which says: "Phelps Dodge is one of the few new companies in the copper-mining industry that is under-capitalized rather than over-capitalized, and this is but a detail in a general business policy that, while thoroughly progressive and abreast with the times, retains the fundamentally sound and conservative policies developed by the old firm in nearly a century of honourable and markedly successful business life."

The Cornish Crisis

Two months ago we made an appeal for the Cornish tin-miner, workless and threatened with starvation owing to the stoppage of the industry on which he depends for a living. Unfortunately the position is rapidly becoming more acute, and the outlook for the winter is undoubtedly very serious. The unemployment dole has automatically ceased, and the distressed are officially thrown on the rates, which are entirely inadequate. Cornishmen are earnestly seeking some satisfactory solution of the difficulty. They are generously raising funds to afford temporary relief, but it is universally held that charity cannot be effective for long, as the purses of the givers are not bottomless in these days, and also that it is of little use to wait for the market in tin to revive. Thus the Cornishmen's endeavours are twofold, one dealing with the raising of funds to afford temporary relief, and the other to find the men some work that will benefit themselves and the county.

As we mentioned in the previous article, the Distress Fund for the Camborne-Redruth Area is doing excellent work. Mr. F. D. Bain, the tin-smelter, is the treasurer of the fund, and the Reverend W. A. Bryant is the active organizer. Mention should also be made of the valuable assistance given to the committee by Mr. Herbert Thomas, of the *Cornish Post*, who has obtained many subscriptions from Cornishmen abroad. There is a separate Distress Fund at St. Just, of which Mr. Richard Nicholas is treasurer, and substantial sums have been contributed to it by the residents of Penzance. Many people are desirous that St. Just should be included in the other area, and that the Lord Lieutenant should be thus enabled to constitute a county fund. Such a rearrangement would greatly add to the influence of the Cornish appeals.

The police, too, are taking an active part in the relief of distress. The Chief Constable of Cornwall, Lieut.-Col. H. B. Protheroe Smith, has issued an appeal for his "Cornish Tin Miners' Relief Fund," and as it clearly reflects the present position and the pressing necessity for help we quote the appeal herewith. Writing from the Chief Constable's office at Bodmin, he says :—

"Owing to the high price of coal during the past few months and previously, and the low price of tin, all the tin mines in Cornwall have been closed down for several months. Of the many men out there are 3,000 who, from the end of September, receive no unemployment dole at all, and it is estimated that they have about 9,000 dependents. About 600 of the younger men emigrated, until emigration opportunities for tin miners ceased. These men and their forefathers have always been miners. Many of them are men of 45 to 55 years of age, with large families. Of the amount which has been raised for them by means of this fund, and is now almost expended, as much as possible has been spent in payment for relief work, and as little as possible in doles. At present we have only sufficient to last until the middle

of October. Food depots have been opened and hundreds of parcels have been given away weekly. The men want work and not doles, and the object of the fund is to keep the men employed on relief work until the mines reopen, and to procure food for the women and children, and also coal. There is a tremendous amount of privation. I will only quote the most recent case which was reported to me last week, and is a typical case of where help is needed. A man, his wife, and nine children, no unemployment pay, sole income 15s. a week from the eldest son, aged 16, except what they get from the Relief Fund.

"I am trying to get all the financial assistance I can for the miners, because: (1) these men never lost a single day's work through being on strike; (2) while the mines were working, in some mines they voluntarily gave up 20% of their pay to try and keep them going; (3) the mines received no subsidy, and no inflated bonus was ever asked for or received by the men during the war; (4) their maximum pay (except the contract men) was 50s., minimum 37s. per week; (5) their conduct up to the present has been exemplary, in fact, wonderful.

"The Cornish Police have voluntarily subscribed £270 (an average of £1 per head) during the last four months, and are still subscribing, and I am collecting clothing through the police all over the county. The Prince of Wales, Duke of Cornwall, has given £300 to the Relief Fund.

"I know the great distress all over the country, but in view of the foregoing, especially where so many women and children are concerned, who have no means of support for the present, very little food, poor clothing, and no coal, I should be very grateful if you could help me with a donation to the fund I am trying to raise, and could mention it to any of your friends."

We endorse this appeal, and have already sent a contribution to the fund. Perhaps some of our readers will follow this example. Colonel Protheroe Smith is a kind-hearted man, as are also Deputy Chief Banfield and Superintendent Smale, who are associated with him in this work. The county police are deservedly popular, for they are tactful and sympathetic and do everything to help the miners and to keep them in good temper and in a reasonable frame of mind. In fact the police in Cornwall and throughout the kingdom are the sincere and discriminating friends of the poor and of those in trouble.

So much for present relief, but the greater question emerges as to how to provide these men with permanent work. In the first place it may be asked whether there is any chance of the mines being reopened. Under ordinary circumstances the answer would be that economic conditions offer little hope for any immediate resumption of work. By those desirous of adopting a more active policy it has been suggested that the mining companies should follow the example of some of the iron-masters and resume operations without any hope of a profit, trusting that the improvement in trade so confidently expected will put them right in the long run. Most of the tin-mining companies, however, are too poor to stand the financial strain involved by such a policy, and the two companies most likely to be able to adopt the policy are at present worried with water and shaft troubles. Another suggestion would be to ask the Government to guarantee to the companies sufficient financial aid to meet their working costs. This proposal is on the same lines as that brought forward a year or more ago to the effect that doles should be diverted to the mines with this desirable object in view. Though the Government refused to listen then, there is reason to hope that with the altered financial condition of the country some such arrangement might receive consideration. On the other hand, some of the mining companies would not take kindly to Government interference, for such co-partnership has proved expensive and irritating in other quarters. If the miners cannot be helped by the reopening of the mines, the only alternative appears to be to start works of public utility. There are at present many such schemes suggested for Cornwall. One that has recently been promulgated seeks to provide for a new drainage system at St. Just. But here, again, the question of finance introduces difficulties, for the Government, the counties, and the boroughs are already so saddled with debts and financial commitments that the raising of the necessary funds will not be an easy matter. Nevertheless, it is the scheme that is most likely to obtain the support of the Government, and before long it is probable that some public announcement will be made on the subject on these lines. Works of this character can, of course, only be considered as temporary expedients and palliatives, and Cornishmen will have to continue to discuss the ways and means of

reopening the mines, or in other ways of providing profitable industrial occupation for those at present deprived of their means of livelihood.

The British Association

After passing through a difficult period of its existence owing to scientists having devoted themselves to the study of war problems and laying on one side for the time the public exposition of new truths and theories, the British Association has gained its old footing this year, and the meeting held in Edinburgh last month was one of the most successful recorded during its existence of ninety years. Being free from war worries the scientists were able to devote thought to the reorganization of the methods of conducting the meetings and to the introduction of improvements in the means of presenting information and raising useful discussion. Those who attended the Edinburgh meeting are unanimous in their praise of the executive, and in expressing the opinion that the British Association is itself again.

In the midst of the prodigal spread of lectures, papers, and discussions, there stood out three which drew general attention and constituted the important features of the meeting. These were concerned with the release of atomic energy, the age of the earth, and isotopes, three subjects which are intimately connected. Readers of the MAGAZINE are fairly familiar with the first two subjects, but probably know little or nothing of isotopes. This word was coined to represent elements possessing the same chemical characteristics and inseparable by chemical means, but having different atomic weights. The name is derived from the fact that they occupy the "same place" in the periodic series of Mendeleeff. From the researches of a number of chemists, of whom Professor F. W. Aston is the chief, it is believed that many elements as known to-day are a mixture of isotopes, a supposition which explains why their atomic weights are not whole numbers. Thus chlorine, whose atomic weight is 35·46, is held to be a mixture of two elements having the atomic weights of 35 and 37. The isotopes making up an element as we know it are quite inseparable by any chemical means, and their existence would only be based on supposition if there were no evidence of the existence of one by itself and freed from its fellow isotopes. It is here that the subject of the release of atomic energy and the breakdown of the atom is connected with that of isotopes, as mentioned above. It has been found in the course of study of radio-activity that when thorium and uranium undergo radio-active disintegration they assume the chemical characteristics of lead and its position in the periodic series, but differ from it in atomic weight. Lead prepared by any chemical method is taken to be a mixture of isotopes that travel together through all current reactions, while lead obtained by the destruction of the uranium atom is a new creation and consists of only one of the isotopes of lead.

As regards the breakdown of the atom and the resulting release of atomic energy, the scientists concerned have not got further than demonstrating this physical fact in the case of radium, and no means of generation of power on a greater scale has as yet been found, so for the present this ultimate source of power need not be considered in these pages. But mining men must keep this future possibility at the back of their heads and thus be aware of the progress of science as it may affect them.

The other subject discussed at Edinburgh to which we have made reference relates to the age of the earth. Lord Kelvin, before the days of radio-activity, had estimated the period during which life could have existed on the earth at a maximum of twenty million years, basing his calculation on the rate of cooling. During recent years it has been discovered that the disintegration of uranium has provided an internal source of heat which has caused this rate of cooling to be far slower than was known to Lord Kelvin. Calculations based on the change of uranium to lead indicate that the figure would be more nearly a thousand million years. There is considerable difference of opinion as to whether the unit of uranium time has been constant or not, and in particular Professor Sollas has shown from a study of bombardment rings in the mica of granite that the disintegration of uranium must have been more rapid in the earlier stages of the world's history.

In all the three branches of the subjects here described the speculations are daring in their conception, but as they are based on undisputed evidence they deserve recognition and consideration. The only point of reservation is how far the reasoning is affected by other factors known or unknown to us at present.

REVIEW OF MINING

Introduction.—The state of trade in this country continues to be bad, and the general position is now being seriously considered by the Government. Everybody knows by now that the remedy lies in harder work for smaller pay, diminution of profiteering on the part of distributors, and a drastic reduction of public expenditure. The only difficulty is to get people to act on this principle. In the meantime mining of all sorts is in a very depressed condition.

Transvaal.—The leading houses continue to discuss the economic situation, more particularly with regard to the management of labour. Consideration is also being given to the engineering side of the problem, for it is generally felt that many improvements could be introduced in mining and metallurgical practice independently of the labour question. It can hardly be denied that the Rand has lagged behind in technical progress. One cause of this backwardness is undoubtedly due to the fact that the control in these matters is far too tightly held by the boards of directors, and that the engineers do not have the free hand they should.

Considerable interest has been aroused by the publication of a cable to the effect that Springs Mines is adopting an all-sliming process. The cable says: "Directors have decided in extending reduction plant to discard stamp battery and plate amalgamation, and adopt all-sliming of ore and direct cyanide treatment. Decision come to as a result of metallurgical experiments, and will result in reduced capital expenditure, probably saving operating costs, increased extraction gold contents." As far as any written communication on the subject is concerned, the only information we have received relates to the elimination of stamps. During recent years it has been the tendency to send coarser material to the tube-mills than formerly, and the openings in the battery screens have been gradually made larger. They are so large nowadays as to make stamping almost supererogatory, seeing that the modern crushers will supply a product suitable for the tube-mill. Thus it is now proposed to eliminate the stamp-mill and the battery amalgamating plates. The other two questions remaining for consideration are, first, the elimination also of amalgamation below the tube-mills, and, second, the abandonment of classification into sand and slime, the comminution of all the ore to slime, and the treatment of the whole in agitators. In this all-sliming method the cyanide solutions would be introduced in the tube-mills. Presumably the cable means that amalgamation is entirely eliminated, and that there is to be only one product for cyaniding. We postpone further discussion until complete information arrives.

The reports of those companies of the Central Mining-Rand Mines group whose financial years end with June 30 have been issued this month. Of these, New Modderfontein is the most important. Here the tonnage milled and the profit are both highest on record, the figures being 1,083,000 tons, as compared with 968,500 tons the year before, and £1,699,052, as compared with £1,493,845. Of the profit no less than £751,427 accrued from premium. The grade of the ore milled was half a pennyweight lower than the previous year, and the cost per ton was up 1s. 6d. An important feature of the development work was the discovery of ore averaging 9·7 dwt. over a large stoping width, 82 inches, in the area west of No. 2 shaft between the 12th and 13th levels. No ore of this character has hitherto been discovered in this section of the mine.

The Custodian of Ex-Enemy Property is visiting London again in connexion with the disposal of the shares under his control in the gold mining and other companies in South Africa, and it is hoped that a scheme will be settled before long between the British and Union Governments.

Rhodesia.—The output of gold during August was returned at 53,200 oz., as compared with 51,564 oz. in July and 48,740 oz. in August last year. The other returns from Southern Rhodesia for August were: Silver, 14,609 oz.; coal, 51,088 tons; chrome ore, 2,676 tons; copper, 263 tons; asbestos, 1,212 tons; arsenic, 10 tons; mica, 3 tons; diamonds, 9 carats.

It will be remembered that the Planet-Arcturus group of gold mines was reopened a short time ago by the parent company, the Gold Fields Rhodesian Development Co., with the object of repaying the cash advances previously made. It turns out now that the costs are higher than expected, so the Gold Fields company has determined to work the higher grade ore only. The reserve at June 30 was 251,034 tons, averaging about 11·8 dwt., but a large

amount of lower-grade ore has now been omitted from the estimate, and the new figures are 139,600 tons, averaging 13·27 dwt. Only this higher-grade ore is now being worked.

Kenya.—The Magadi Soda venture is still hampered in its progress by various economic factors, and the financial result for 1920 was a debit of £159,326, bringing the total adverse balance to £357,000. At first sight it might be thought easy to market these vast deposits of natural soda, but their development was blocked during the war in many ways, and then the trade opposition is powerful. Those who are acquainted with the chemical business know how hard it is for a new-comer to secure a market even for a commodity in universal demand. The Magadi enterprise is in the hands of strong people, the Shell and the Central Mining groups, and they will surely win through eventually. Production and sales started last year, and have increased slowly and steadily since.

Nigeria.—In June last it was mentioned that the Naraguta Tin Mines was developing alluvial gold prospects in the Birnin Gwari and Kano regions. The necessary pumping and crushing plants have since been acquired, and we are informed that Mr. Clyde Allen is leaving London for Nigeria about the middle of next month for the purpose of organizing a comprehensive campaign of exploration and development.

Australia.—It is announced that the Electrolytic Zinc Company of Australasia, whose works are at Risdon, Tasmania, has made a contract with the British Government to take 750,000 tons of zinc concentrates over a period of years. Presumably this contract will help to relieve the British Government of part of its burden, but further details are necessary before the exact influence of the contract can be ascertained. In the meantime the stocks of this product are accumulating at an increasing rate, and in addition the Broken Hill Proprietary has decided to resume production of this article. The following table gives in actual cash the Government disbursements to the mines during the five months April to August :—

	Tons	£
April .	. 11,943	53,743
May .	. 14,085	63,382
June .	. 16,677	75,046
July .	. 17,758	79,911
August	. 22,418	100,881
Totals	. 82,881	372,963

The Gold Producers' Association of Australia report that during July 89,888 oz. of standard gold was sold, realizing an average net price of 101s. 9d. per oz., which is equal to 112s. 9d. per oz. fine. The net premium received during the months January to June was £444,636, which represents 21s. 10d. per oz. fine on the gold sold. Of this amount £144,544 was distributed among members of the association on May 30, and the balance on August 25.

At the Sons of Gwalia mine the plant for the re-treatment of sand and slime was started on September 20. It will be remembered that the mill was destroyed by fire early this year. The present announcement indicates a resumption of gold production. The new main plant will be ready later.

A cable message announces the closing-down of the Mount Bischoff tin mine in Tasmania, owing to the unfavourable conditions in the tin market. For some time this celebrated mine has been yielding only low-grade ores, but there is no reason to think that the closing is final, for the last fortnightly reports to hand by mail refer to increased provision for roasting the pyritic ores.

A serious explosion occurred last month at the Mount Mulligan colliery, North Queensland, operated by the Chillagoe Company, when over fifty men lost their lives. The disaster is all the more to be deplored because the coal and coke are relied on for many metallurgical operations in this region. Particulars of this coalfield were given in our issue of February, 1918.

India.—The scheme for raising further capital for Champion Reef has now been put before shareholders. The capital of the present company is £260,000, in shares of 2s. 6d. each ; a new company is to be formed with the same nominal capital, but divided into shares of 10s. each, of which one will be given credited as 4s. paid for every four in the old company. This may seem a very drastic reconstruction, but it must be remembered that most of the shares in the company were issued at high premiums, and that holders have paid far above par for their shares and have received big dividends for many years. The output of gold has fallen considerably lately, so that it has been necessary to draw on the reserve fund for expenditure on capital account, usually met out of revenue, and also restrict the amount of development. The funds now raised are required for further development, and for

additional expenditure to provide for deeper operations.

At the Balaghat mine the lode has been intersected on the 1,200 ft. level south where the assay-value of the ore is 15 dwt. gold per ton over a width of 4 ft. This is the lowest level in the mine.

The Indo-Burma Oilfields, Ltd., has made an issue of £250,000 debentures for the purpose of developing its properties. The company was formed last year for the purpose of acquiring property in the Yenangyaung oilfield, particularly at Yenanma, Padaukpin, and Okpon. Col. H. H. Johnson and Mr. S. C. Sampson are the engineers in charge. Co-operative arrangements have been made with the Yomah Oil Company, of which Dr. Arthur Holmes is the manager, for drilling and also for refining.

Cornwall.—A second appeal for aid for the out-of-work tin miners is made in another part of this issue. This appeal is now being actively backed by many of the leading London daily papers. We do not hear of any likelihood of mining being resumed anywhere at present.

No further news is to hand with regard to the position at East Pool and South Crofty, but there appears to be some prospect that the two companies will not go their own ways independently, as might be inferred from the announcement by East Pool, recorded in our last issue. It would not be advisable for us to say more than this at present.

Lead and Zinc in Britain.—A more reasonable attitude is now being shown by the unions who control the doings of the lead miners, and it may be possible to resume work here and there. At Wanlockhead, in Dumfries, the men have signified their willingness to try the owners' terms. It is not likely that any zinc will be mined anywhere in Britain, for the demand for British concentrates has vanished. As regards the reopening of zinc smelters, the Villiers works at Swansea is being started on half capacity as a trial, but none of the other companies shows any inclination for resumption.

Canada.—A circular has been issued by the Kirkland Lake Proprietary Company, which announces that the continuation of the faulted No. 2 lode on the Tough Oakes has been found in a cross-cut from the 500 ft. level; also that a cross-cut driven since on the 300 ft. level has intersected the upthrown lode. This part of the lode is in the Burnside property, and future development will be done from the Burnside No. 3 shaft. Mr. W. H. Goodchild is now making a geological examination.

Colombia.—The Colombian Mining and Exploration Company has issued a statement to the effect that the new mill for the treatment of the Marmato gold ores, as outlined in September of last year, is in course of construction. It is hoped to have the first unit, which will be of a capacity of 3,000 tons per month, ready by the end of January, and the remainder, bringing the capacity to 10,000 tons, by the end of March.

Bolivia.—As already recorded in these columns, the Aramayo Francke Mines, Ltd., has changed its domicile to Switzerland, where the company is now known as the Compagnie Aramayo de Mines en Bolivie. The completion of the transfer of the property was effected on December 23, 1920. The Swiss company now issues a report for 1920, and the accounts are in Swiss francs. The market here converts the figures into pounds at 22·50 francs per pound. Thus the profits are given at £234,500, as against £663,900 for the previous period, 19 months ended December 31, 1919. The dividends distributed were £119,440, being at the rate of 20%, as compared with £179,127, or 30% for the previous period. The balance, which is a large one, is kept in hand, so that the company shall preserve its strong position in these doubtful times.

Portugal.—The directors of Mason & Barry, Ltd., the company which has worked the San Domingos pyrites mines at Mertola for fifty years, announce that negotiations are in hand that may lead to the sale of the properties, but no details of any sort are given.

Czecho-Slovakia. — The Imperial and Foreign Corporation, of which Mr. Herbert Guedalla is the head, has become interested in the Joachimsthal uranium-radium mines, in so far as the marketing of the products is concerned. For the purpose of conducting the business the corporation and the Czecho-Slovak Government have formed a company called the Czecho-Slovak Company for the Exploitation of Radium. A large consignment of radium bromide has already arrived in this country, and the best way of deriving an income from it is now being devised. We have not yet heard of any pressman alleging that the presence of this radium accounts for the abnormally hot weather now being enjoyed in London.

TRINIDAD:

A REVIEW OF ITS GEOLOGY AND OIL RESOURCES

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In the following article the author summarizes our present knowledge of the geology of the Island of Trinidad, with special reference to the mode of occurrence and storage of its oil. An account is given of the progress of development of the petroleum resources, and some of the more important technical difficulties encountered during oil exploration in the Island are discussed.

(*Concluded from September issue, p.* 148.)

ECONOMICS.

The geological history of Trinidad during Tertiary times embraces three quite distinct phases of sedimentation with which the occurrence of petroleum in the island is intimately related. It has been found that for the main oil-producing region in the south, two petroliferous groups of strata are recognizable, a lower and an upper; the lower corresponds to the Eocene-Oligocene (in part) phase, the two together sometimes known as Palæogene, and represents a period of marine transgression in which essentially marine sediments were laid down in the north (Naparima area), and shallower water deposits in the south (Siparia, Erin, etc.). The upper group corresponds to the late Oligocene and Miocene (in part) phase, during which the pre-existing ocean basin was rapidly filled up by excessive sedimentation, producing abundant arenaceous material and a marked absence of calcareous facies, characteristic of the lower group in the Naparima area. The third phase constituted by the late Miocene and Pliocene epoch was a period of orogenic movement, and the uplift occasioned a still further shallowing of the sea, with concomitant production of estuarine and even terrestrial deposits, now represented by the Moruga series; a certain amount of oil occurs in association with this series, but it has probably all migrated across the unconformity from the underlying Naparima beds, the uppermost beds of which constitute the main oil horizons now being tapped. The lower oil-bearing group is not so well known on account of the great depths at which the oil-sands often lie; further reference will be made to this ultimately. With regard to oil production from the Moruga beds, it is important to remember that we are here dealing with beds laid down subsequent to the main Tertiary folding of the region (Middle Miocene), and whose relationship to the underlying series is one of marked unconformability; in consequence, production from wells put down entirely in Moruga beds may be, and often is, of a sporadic nature.

The surface indications of petroleum are extremely numerous in the island; these include the usual oil and gas seeps, mud-volcanoes, asphaltic deposits such as the famous Pitch Lake, and manjak veins. Oil seeps occur very frequently, as for example at Lizard Springs, La Brea, along the Vance River, and at Point Ligoure. Mud-volcanoes are also widely distributed, and they often have a special significance. As in other countries, two main types exist, the simple and the compound; the former consists of a single cone commonly attaining as much as 20 ft. or more in diameter at the base; an exceptional example of this type is seen in Columbia Estate, ward of Cedros, and is known as the "Columbia Chimney," in which the crater alone is 150 yards in diameter, according to Cunningham Craig.[21] The compound type is made up of a series of overlapping smaller cones, varying from a few inches to two or three feet in diameter, these often initiated on the slopes of a much larger simple cone; an example of this is the "Devil's Woodyard" near Princes Town. Other well-known examples of mud-volcanoes in Trinidad are the "Chemin de Diable," south coast of the island, and those at Galfa Point and Islot Point. Their distribution is frequently in a definite direction, corresponding to the trend of important fracture lines; such lines are developed as a result of anticlinal flawing and faulting, particularly in pitching structures. On this account the existence of mud-volcanoes is to many a warning not to drill rather than a good indication, since it pre-supposes fracture and escape of oil, rather than subterranean storage.

Of the solid or semi-solid asphaltic indications, no finer example exists than the famous Pitch Lake at La Brea (Fig. 4*a*). This has an area of about 137 acres and consists of an emulsion of bitumen, sand, and water, solid at the surface, but becoming soft and

viscous in depth, and also in the central parts of the lake. Its maximum thickness is 135 ft., but it shallows considerably towards the margin; the estimated amount of asphalt present is about nine million tons, and notwithstanding the quantity of material already removed, the level of the lake has only sunk about 8 ft., due to the fact that the rate of influx of fluid asphalt beneath tends to counterbalance the amount removed from the surface. Superficially the deposit exhibits the formation of broad folds on a large scale, due to constant motion of material from centre to periphery (Fig. 4*b*); water collects in the troughs of these folds and gas is frequently

Fig. 4a. Plan of Pitch Lake, La Brea.

seen bubbling through it, which on analysis proves to be a mixture of methane, carbon dioxide, hydrogen, and water.[22] Several "islands" composed of sandy cover rock occur in the lake, on which shrubs and small trees thrive; these islands are in slow but continual movement from point to point over the surface of the asphalt, dependent on the motion of the latter.

The methods employed in mining the deposit are quite simple; the asphalt is hand dug, loaded on to trolleys actuated by cable along a rail track (which can be easily shifted as work progresses and also when sinkage occurs), carried by inclined cable for nearly a mile to the wharf, where it is tipped into steamers for export. In 1916, 131,099 long tons of this lake asphalt were exported, of which 13,380 tons went to Europe and 117,719 tons to the United States. Shipments in 1918 and 1919 amounted to 74,504 and 93,951 tons respectively.

Abraham gives the following analysis of the crude material from the centre of the lake[23]:—

Water and Gas volatilized at 100° C.	29·0
Asphalt soluble in carbon bisulphide	39·0
Asphalt absorbed by mineral matter	0·3
Mineral matter on ignition	27·2
Water of hydration in mineral matter	4·3
Total	99·8

Further, after pulverizing and drying to constant weight, analysis gave the following results:—

Asphalt soluble in carbon bisulphide	55·0
Free mineral matter	35·5
Water of hydration, etc.	9·7
Total	100·2

Refining the crude material consists in heating it to 160° C. to drive off water and small amount of volatile constituents; thus purified, the asphalt has a jet-black colour, a somewhat dull lustre, marked conchoidal fracture, and a specific gravity of 1·41 (varies slightly).

The constant motion of this lake asphalt referred to above tends to cause its movement downhill towards the sea, the lake being 138 ft. above sea-level; this results in the production of a large stream of "land asphalt" (Fig. 4a), different in composition from the lake deposit and varying with duration of exposure to atmospheric weathering. This land asphalt is also typically solid at the surface and three varieties are known locally, "cheese pitch," "iron pitch," and "cokey pitch"; the first is characterized by the development of gas cavities, giving it a gruyère-like appearance; the iron pitch is exceedingly hard as a result of continual weathering, and the cokey facies is the product due to carbonization by local

[21] E. H. Cunningham Craig, Oil Finding, 1917, p. 105.

[22] H. Abraham, Asphalts and Allied Substances, 1918, pp. 108–15.

[23] H. Abraham, op. cit., and references there quoted. See also Clifford Richardson, Proc. Am. Soc. Testing Materials, 1906, 6, p. 509, also Modern Asphalt Pavement, 1908, p. 176. Analyses were also given by P. Carmody in his paper on "Trinidad as a Key to the Origin of Petroleum." See footnote (1).

shrub fires, etc. This land asphalt differs from the lake asphalt in containing no gas or water, a higher percentage of mineral matter, and a lesser percentage of volatile constituents.

Besides these lake and land asphalts just described, there are deposits of manjak in the island, mainly found as veins and fissures in the Tertiary rocks of the San Fernando area, and elsewhere; it occurs in sufficient quantity in Trinidad to make its exploitation worth while, and is mined especially at the Marabella and Vista Bella mines. Carmody has given the results of several analyses made on this material, and these show a fluctuation of between 84% and 95% of pure bitumen.[24]

Thus the lake asphalt and the manjak constitute the principal solid forms of petroleum in the island; ozokerite, the natural paraffin wax, though reported from Trinidad, seems to be of very doubtful occurrence there.

Geological Age.	*Horizon.*	*Remarks.*
4. Pliocene (Up. Tertiary).	Moruga Series, "La Brea Oil-sand."	Migrated oil. Heavy, Asphaltic base. Sulphurous. S.G., 0·950, average.
3. Miocene (Mid. Tertiary).	Naparima Series, "Rio Blanco Oil-sand" or Upper Oil Group.	Asphaltic oil. Low sulphur content. S.G., 0·908, average. Chief producing horizon.
2. Palæogene (Lr. Tertiary).	Galeota sands, Lizard sands or Lower Oil group; divisible into two, an upper and a lower Oil-sand.	High grade light oil. S.G., 0·840, average.
1. ? Cretaceous.	(Tabaquite Oil-field, Central Range).	Paraffin base oil. S.G., 0·796.

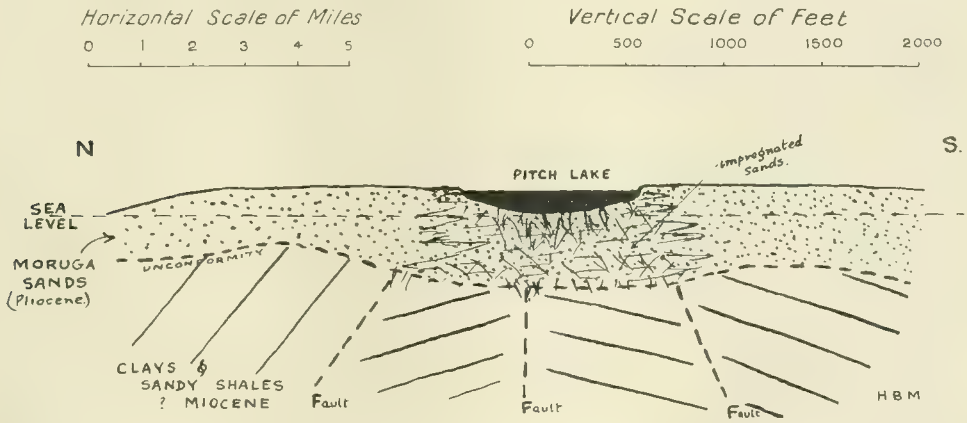


Fig 4 (*b*) Section across Pitch Lake, La Brea
(Based on Wall and Sawkins, and Others.)

Passing now to the oil itself, reference has already been made to the principal stratigraphical horizons from which it is obtainable; we may summarize these as follows:—

Generally speaking, a heavy asphaltic fuel-oil is characteristic of the island, and is obtained chiefly from the Upper Oil group; paraffin and mixed base oils also occur. Carmody has given details of several analyses of liquid and semi-liquid oils from Trinidad, in which the specific gravities of various samples range from 0·796 as at Tabaquite, to 0·977 as at Fyzabad.[24]

With regard to the above horizons, the Tabaquite oil is usually supposed to be from a pre-Tertiary formation, that is,

[24] P. Carmody, "Trinidad as a Key to the Origin of Petroleum," a paper read before the Inst. Pet. Tech., May 10, 1921, as yet unpublished, but a résumé occurs in the *Petroleum Times*, May 21, 1921, p. 585, including analyses of oils. For Manjak see also E. H. Cunningham Craig, "San Fernando Manjak Field," Council Paper No. 3 of 1905, Trinidad, 1905.

Cretaceous sandstone, but geologists are not all agreed on this point, some suggesting that it is a pre-Cretaceous oil, others that it is a Cretaceous oil, and yet others that it is a Tertiary oil. A more recently favoured theory suggests that the oil has accumulated in its present position by downward migration from overlying Tertiaries, now removed by denudation, a theory currying favour in somewhat anomalous oil occurrences in other countries besides Trinidad. The Lower Oil group or Galeota Sand horizon produces, as at Lizard Spring, a very high-grade oil with large percentages of petrol and kerosene. The Upper Oil group (Rio Blanco Oil-sand of Cunningham Craig) is the most important producing horizon at present, and the oil is of a heavy asphaltic type with varying specific gravity; in the Point Fortin fields for example the S.G. varies from 0·907 to 0·945, while at Fyzabad it is as much as 0·977. The La Brea Oil-sand, as already stated, is essentially a horizon of migrated oil, characterized by its high specific gravity (0·950), and its sulphurous content.

A striking feature of the petroleum produced in Trinidad is the marked variation shown in composition, as evidenced by the great differences in specific gravities, percentages of petrol, kerosene, lubricating oil, sulphur, and solid residues as a result of refining; the occurrence of such a variety of oils suggests either formation originally under constantly changing conditions of deposition, or subsequent alteration in character as a result of inspissation and allied natural processes. Very probably both factors have been at work in the present instance, for we have already seen how the physical conditions altered with the growth of the Tertiary epoch, and furthermore observed cases of natural filtration are quite common in the island; in this connexion Cunningham Craig has described an interesting example at Lizard Spring, to which account the reader is referred for further information.[25] Obviously a consideration of these facts throws us back to the question of the origin of Trinidad oil, and unfortunately this still remains an unsolved problem for most people; it is not as though we were dealing with a definite oil horizon as well individualized as the Monterey Shales of Californian fields, for instance, where an associated diatomaceous fauna is indicative of the origin of the oil, thus indigenous to these rocks; in Trinidad the evidence is much more obscure, and apart from the problems of the relationship of one oil horizon to another, in themselves formidable enough to solve, so far no generally accepted theory has been propounded to explain the phenomena observed. The recent paper by Professor Carmody is mildly constructive in suggesting "Trinidad as a key to the origin of petroleum," but it lacks comprehensiveness in narrowing down the question to a vegetable origin which, while capable of explaining the occurrence of certain oil-pools in the island, is inadequate to all cases both here and in other parts of the world, as for instance in the Californian example cited above. A special plea of that author's work, however, that of close collaboration between geologist and chemist, is certainly sound, and this combination, if not initially successful in solving the local problems of Trinidad oil, may ultimately be expected to provide a solution to the question of the origin of petroleum in a broad sense, from which suitable deductions may be drawn to meet the special circumstances of cases such as the one under discussion.

It remains to mention in this economic section coals and lignites occurring in the island; these may be dismissed briefly as they are of little commercial value. The coal deposits are not extensive, and the material is of poor quality; they occur particularly at Cunapo and Montserrat, the coals of the latter locality being decidedly bituminous. Lignites, also of poor quality, occur at Chaguanas and Brasso Caparo. It is noteworthy that the above occurrences are not located in the main petroliferous region of the island.

Production of Petroleum.

One of the most characteristic features of the oil reservoirs in Trinidad is their strong tendency to exhibit lenticular disposition, particularly in the case of the upper oil horizon; these reservoirs usually consist of sand lenses intercalated with argillaceous strata, and their occurrence is determined primarily as a function of estuarine and deltaic deposition, subsequently modified by the nature and degree of deformation undergone by the enclosing strata. We have already seen that on the whole the varying phases of deposition of the Tertiary

[25] E. H. Cunningham Craig, Oil Finding, 1917, pp. 91–2.

rocks of the island are indicative of shallow water conditions, and the presence of these lenticular sand masses is clearly incompatible with deep-water sedimentation, a factor receiving support from the marked lateral variation in lithology of the deposits, previously remarked. The usual textbook diagrams of lenticular oil-pools, however, can hardly be accepted as truly illustrative of actual conditions, and the contrasted behaviour of wells often in close proximity is not so easily explainable on the assumption of the existence of several small lenses, as on this factor of lateral variation with its attendant differences of porosity of sediment. The accurate location of these structures is one of the most difficult tasks facing the geologist, and in regions of extensive folding of strata, as in Trinidad, such difficulty is doubly accentuated; it obviously implies a fundamental knowledge of the mode of origin of the sediments, their lithology, variation, and mutual relationships, supplemented by a careful study of the records of existent wells and by all the power that modern field and laboratory methods may bring to bear on the questions concerned. Then with a clear idea of the attitude of these oil-pools in depth, the subsequent location of well sites becomes a comparatively straightforward matter, and it may be safely said that the failure of many wells put down in Trinidad, as in other countries, is due largely to insufficient "ground work" in minimizing risk, quite apart from failure due to adverse circumstances over which the geologist has no control. There is a further element to be considered in this respect and that is the frequent antipathy shown by drillers to the geological staff; the gulf between them is unfortunately often a wide one, not only in some cases in Trinidad, but also in other oilfields. That it can be successfully breached by tact and collaboration of both parties is the opinion of more than one field manager known to the writer. The point is not by any means irrelevant to prosperous oil production.

Drilling is not easy in Trinidad for many reasons, chiefly owing to the rapidly changing characters of the strata, and also on account of the high gas pressure frequently met with; in many cases the sands cave badly, and this, coupled with the fact that the rocks are often dipping at fairly high angles, tends to cause delay. Water again sometimes gives trouble, and in such instances prolonged bailing has to be resorted to before production can be obtained. In areas of excessive gas pressure the buckling of casing previously lowered into the hole is of frequent occurrence; where this cannot be overcome by temporary expedient, the well has to be sealed off, and an "offset" put down at a more pertinent location. Gushers are common in some fields, and that of Apex No. 3 in November last is still fresh in the public mind; in this case a gross flow of at least 100,000 barrels of oil in eighteen hours occurred, a dam capable of holding back 50,000 barrels being washed away, the well ultimately catching fire and causing much damage. Happily, disasters on this scale are the exception rather than the rule, and usually, thanks to the ability of the drilling engineers in charge, there are comparatively few wells which come in with a "blow" that are not ultimately brought in satisfactorily, with little, if any, loss of oil.

Generally speaking, the wells are from 600 to 2,000 ft. deep, though there is no specific reason why deeper wells should not be drilled if, ceteris paribus, prospects suggest the advisability of so doing. Both standard percussion and rotary flush systems are employed, and latterly the combination of the two has been favoured, that is, starting with percussion and changing over to rotary usually at about 500 to 700 ft., though this may vary according to circumstances. As in other oilfields, however, there is no rigid rule as regards method, and each well put down is drilled according to the system best befitting the conditions obtaining in the particular area selected.

Oilfield Development.

It is not surprising, in view of the potentialities of Trinidad as an oil-producing colony, that development of its petroleum resources has been rapid, largely owing to the enterprise of British companies. The following table of the annual production of oil from 1905 gives some indication of the course of events:—

	Imp. Gallons.
1905–1909–10	368,934
1910–11	4,378,942
1911–12	9,985,748
1912–13	17,626,563
1913–14	22,523,060
1914–15	36,753,931
9 months ending Dec. 1915	23,489,362
1916	32,475,695
1917	56,080,914
1918	72,872,398
1919	64,436,632
1920	72,905,947

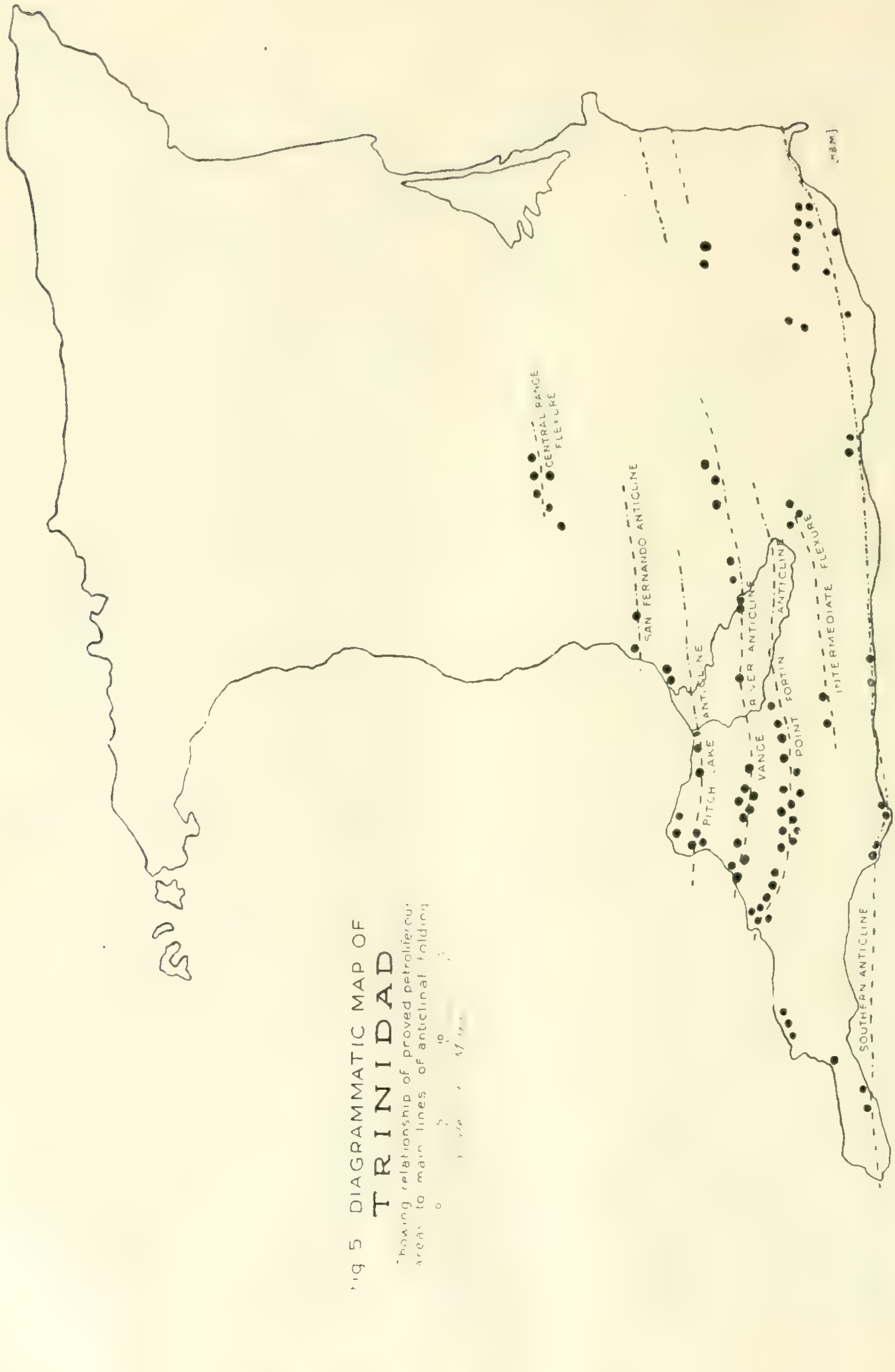


Fig 5 DIAGRAMMATIC MAP OF TRINIDAD
Showing relationship of proved petroliferous areas to main lines of anticlinal folding
0 5 10 Miles

From the above statistics it will be seen that, on the whole, the production of oil has been steadily on the increase; the dropping off in output in 1916, and again in 1919, was due to a variety of circumstances connected with the war, though in the latter case, apart from general financial depression, shortage of material, and increased costs of production prevalent, this falling off was not wholly without natural cause, a marked decline in output being noted from several of the best wells put down. While certain people were at once pessimistic enough in predicting a gradual future decrease in production thence onwards, the consensus of opinion of geologists and others best qualified to judge the trend of events in the island showed little belief in such prognostication, and the official returns for 1920 completely justify the more favourable view. We revert to the question of decreased output of oil from natural causes subsequently.

At the present time the development of the petroleum industry in Trinidad is in the hands of some thirty or more companies, some of them long established, others comparatively newcomers; by far the largest producing company is the Trinidad Leaseholds, Ltd., which has an average monthly output of some 15,000 barrels. The greatest activity from the standpoint of actual production is in the south-western portion of the island, from San Fernando to Cedros, while considerable developments are in progress in the Fort George, Piparo, Williamsville, Montserrat, and Tabaquite districts of central Trinidad. In the following description of the various oilfields it is convenient to deal with them geographically under three regions, (*a*) South-Western Peninsula, (*b*) South Coast and South-Eastern Trinidad, and (*c*) Central Trinidad.[26]

(*a*) *South-Western Peninsula.*—This includes the region to the west of a line drawn from San Fernando through Princestown to Moruga, and comprises some of the most important oilfields as yet developed in the island. In the vicinity of San Fernando itself, several interests are represented, including the Naparima Oilfields of Trinidad, Ltd., which are developing the oil resources of the Ste. Madeleine Sugar Co's. estates, comprising over 16,000 acres. To the south, the Trinidad Leaseholds, Ltd., are operating at Barrackpore, an area of 1,000 acres acquired from the Trinidad Oil and Transport Co., Ltd., in 1918; a 6 in. pipe-line has been laid connecting up with the company's main pipe-line from Forest Reserve to the shipping port at La Carrière (Point-a-Pierre). To the south of this property the Trinidad Central Oilfields, Ltd., hold prospecting rights over about 800 acres. West of the Oropuche Lagoon, the Trinidad Leaseholds, Ltd., are operating their Forest Reserve field in the Fyzabad district, with a subsidiary field at Santa Cecilia to the east; in the former field forty-six wells are now producing, and a 6 in. pipe-line exists thence through Santa Cecilia to La Carrière, a distance of 26 miles. Development of the Santa Cecilia field is in progress. In this Fyzabad district, the Apex (Trinidad) Oilfields, Ltd., have their properties, covering an area of some 800 acres; it was here that the gusher struck at well No. 3 occurred last year, to which reference has already been made; this well is now producing again. Further to the west the United British Oilfields of Trinidad, Ltd., have properties in the Guapo and La Brea districts, while the Trinidad Dominion Oil Co., besides other properties in the south-east of the island, holds some 530 acres under lease at Point Rouge. The Trinidad Central Oilfields, Ltd., also have 483 acres in the Guapo district, and other smaller companies are operating in the vicinity, which includes the Crown Lands in the Morne L'Enfer Reserve, over which the Petroleum Development Co. have prospecting rights. To the north the Pitch Lake is in the hands of the New Trinidad Lake Asphalt Co., Ltd., while the Trinidad Lake Petroleum Co., Ltd., have the oil rights on this property; there is a refinery and shipping wharf at Brighton, just west of La Brea, from which both oil and asphalt are exported. The United British Oilfields of Trinidad, Ltd., control altogether some 38,000 acres in the island, of which part is located in this peninsular region. Several properties bordering the south coast and extending eastwards towards Moruga await future development by the companies concerned.

(*b*) *South Coast and South-Eastern Trinidad.*—This region is embraced by a line drawn

[26] For reasons both of expediency and space, it is impossible to do more than mention briefly the chief companies and their properties in the Island; for further information, reference must be made to the various company reports published and to the well known "Oil and Petroleum Manual," 1921, by Walter R. Skinner.

from Moruga Point northwards through the Fort George area, thence east to Mayaro Point. The greater part of this district is undeveloped as yet, four companies having the chief interests therein. Trinidad Leaseholds, Ltd., hold under lease from the Government about 40,000 acres to the west and north of Guayaguayare Bay, just west of Galeota Point ; circumstances of war, and inadequate storage capacity and transport facilities have retarded development of this property, but considerable geological survey work has already been carried out. Trinidad Central Oilfields, Ltd., also have properties here, 974 acres at Lizard Springs and 42,216 acres at Mayaro, part held on lease and part on exploration licence ; the other two companies concerned are the United British Oilfields of Trinidad, Ltd., and the Trinidad Dominion Oil, Ltd., the latter property bordering Guayaguayare Bay and adjoining the Trinidad Leaseholds field.

(c) *Central Trinidad.*—In the central part of the island, the Trinidad Central Oilfields, Ltd., have had their enterprise rewarded by the development of the well-known field at Tabaquite, being part of a property covering some 25,730 acres, of which over 1,000 acres are held on lease ; the port of shipment is at Claxton Bay, a little to the north of Point-a-Pierre, where the company has a small refinery connected to the field at Tabaquite by a pipe-line, the distance being 18 miles. Trinidad Leaseholds, Ltd., also have oil rights over certain smaller areas in this region, as at Piparo, where developments are in progress. Following on the success achieved by the Trinidad Central Oilfields, Ltd., in this part of the island, proving the existence of valuable high-grade light oil, considerable attention is being focussed on this region, previously regarded as an unlikely area of commercial oil production. In the map (Fig. 5) the distribution of the proved petroliferous areas is shown, together with the main lines of anticlinal flexure previously described.

Conclusion.

The logical sequence to a descriptive article such as this is naturally a reference to the future oil prospects of the island, possibly almost as elusive a subject as much of its internal geology ! Many different opinions are expressed on this point, and one constantly hears the remark that "Trinidad is being overdone," at least on this side, for it is seldom made by those who have had long experience in the island. Mention has already been made of the noticeable decline in production of 1919 ; this now requires a little more detailed explanation.

The bulk of the producing wells in Trinidad have hitherto tapped the resources of the upper oil horizons, the lower in many cases lying at great depths, though not outside ultimate drilling range. This is particularly the feature of the south-western part of the island, where, although the lower sands have been proved to exist, test wells put down for the purpose of exploring the deeper oil-pools have frequently met with trouble in the shape of excessive gas pressure or strong oil-flows from overlying members of the upper oil series ; a case in point is that of a certain well put down with the intention of tapping the lower series, thought to be about 1,800 ft. below the surface, which instead struck a strong gas and oil zone at less than half this depth ; production has since been maintained from this upper horizon, and so far it has been found quite impossible to deepen the well. An instance such as this is not of isolated occurrence, and it clearly points to the persistence of as yet untapped resources nearer the surface. While there may be a tendency towards decline in production from these upper sands taking the region as a whole, one can hardly see grounds for pessimism on this account, since obviously as the upper horizons get further drained, so the gas pressure and strength of oil-flow will tend to be lessened, thus making it possible to sink deeper wells in order to tap the lower resources. And from the little we already know of these lower sands, they bid fair to be equally as important ultimately as the upper horizons have been hitherto. Further than this, there are the developments referred to in the central parts of the island, where comparatively little is known of the geological conditions ; if Tabaquite is anything to judge the future of this region by, we perceive even greater possibilities here than in the south. Add to this the potentialities of much of the undeveloped land in the south and eastern parts of the island, and it is abundantly clear that the petroleum resources of Trinidad are by no means exhausted.

Lastly, the writer may perhaps be permitted to voice the plea for greater publicity

of geological data accumulated by the geologists of the several companies concerned in oil exploration in Trinidad, and this for the benefit of both science and commerce. It is not too much to say that of no oilfield in the world of the importance of Trinidad is so little known to the general public as in this case, and it is extremely difficult to understand the traditional iron-clad secrecy prevailing among the various operative interests in this colony. Once a company has established itself on a definite property, is producing from this property, and has thus proved its economic value, what possible advantage can be served by withholding the details of the scientific evidence by which such results were achieved? We have only to study the admirable reports and technical literature extant in the United States, where every oilfield has adequate publicity in the bulletins and memoirs of the various State surveys and mining bureaus, to be regretful at the lack of similar descriptions of our own fields, and although it may be argued that no official geological survey now exists for Trinidad, that in itself is no reason for the deficiency in this case. Collaboration of the several experts professionally engaged on oil exploration and the pooling of that scientific knowledge obtained in the course of their work for both mutual and public benefit, can scarcely be detrimental to commercial interests in the long run; on the contrary, by such co-ordination future developments would tend to be carried out on a much sounder basis, that of a wider geological knowledge, and increased efficiency both in exploration and production would necessarily follow. Professor Carmody's vindication of "team work," alluded to in the introduction, may be again emphasized here, and it deserves well of those in whose hands the future of the petroleum industry of Trinidad lies.

(*Concluded.*)

Mining in Devonshire

In the Summary of Progress of the Geological Survey of Great Britain for 1920, Donald A. MacAlister gives tables of output of various minerals in Devonshire in years gone by.

Outputs of Lead, Silver, Pyrites, Arsenic, and Iron.

Lead Ore, 1845 to 1913	Tons	59,422
Lead, Metallic, extracted from above ore	Tons	38,423
Silver extracted from the above lead, 1852 to 1913	Oz.	948,291
Pyrites, Iron and Arsenical, 1853 to 1913	Tons	101,266
Arsenic, Soot and White, in addition to the Arsenical Pyrites, 1853 to 1913	Tons	98,067
Iron Oxides, 1853 to 1913	Tons	344,584

Of the lead ore produced the largest amounts came from the parishes of Beer Ferris, 25,670 tons, and Christow, 22,550 tons. The parish producing the largest amount of pyrites was Tavistock, 72,000 tons, of which 50,393 tons was arsenical. The iron oxides were partly magnetite, hematite, limonite, and shining micaceous ore. The last-named has been a feature of iron mining in Devonshire, and it has been worked from time to time at several places, being employed in the manufacture of protective paints. In the following table relating to tin and copper we give the details of output of each parish.

Outputs of Tin and Copper by Parishes.

	Tin Concentrate. Tons.	Copper Ore. Tons.	Copper derived from the Ore in previous column. Tons.
Ashburton	804	421	17
Beer Ferris	10	205	13
Belstone	1	4,036	375
Bovey Tracey	—	2,300	86
Buckfastleigh	—	29,680	1,965
Buckland Monachorum	12	24,250	1,400
Chagford	60	—	-
Dartington	56	—	—
Holme	6	—	—
Ilsington	91	—	—
Lamerton	61	22,600	1,285
Lydford	295	—	—
Manaton	203	—	—
Marytavy (including Peter Tavey)	408	43,250	4,015
Meavy	400	—	-
Molland	—	1,180	75
North Bovey	1,314	—	—
North Molton	—	4,515	638
Okehampton	—	2,656	186
Plympton St. Mary	1,300	240	12
South Tawton	—	6,285	344
Sydenham Damarel	—	80	5
Tavistock	300	933,210	59,682
Walkhampton	220	280	21
Whitchurch	515	20,630	1,538
Others	10	1,150	80
Totals	6,066	1,096,968	71,737

MINING MODELS AT SOUTH KENSINGTON

This article contains an account of models explanatory of mining operations, designed and made by Mr. G. W. Leech, M.Inst.M.M., and recently added to the Science Museum, South Kensington.

The Science Museum at South Kensington is not so well known as it should be, nor does it receive the support from the Government that teachers and students would desire. The collection of plant, models, etc., relating to mining shows considerable unevenness, and there are breaks in the historical connexion. This condition is caused by variations in the interest taken by those in charge. Fortunately for the mining profession, the director of the Museum from 1911 to 1918, Sir Francis G. Ogilvy, was much interested in these subjects, and his services in helping the Royal School of Mines as well as the Science Museum are well known. During his regime a great many new models and apparatus were added, so that the collection and also the new catalogue are now of much heightened value. During the years 1915 to 1917 and 1918 to 1920 Mr. G. W. Leech, M.Inst.M.M., was engaged in designing and building models illustrating mining methods. Altogether about forty of these models have been added to the collection, and we take this opportunity of thanking Sir Francis and Mr. Leech, on behalf of the mining profession, for the excellent services they have rendered in the cause of technical education.

To give readers an idea of the nature of the new work, we reproduce in this article descriptions of five models, together with photographs, the descriptions being taken from the official guide-book to the collection. It will be seen that this guide-book constitutes quite a useful exposition of modern methods of mining.

(1) *Flat-Back Stoping, Overhand System.*—In this method of stoping the ore is broken out in a series of slices of more or less regular shape extending the whole length and width of the vein between the winzes and walls, keeping the back (roof) as uniform and level as the nature of the ore will permit. The model represents a contact ore deposit between a granite foot-wall and a schist hanging wall (that is, a good foot-wall but a weak hanging wall); the ore is supposed to stand well. As the ore is removed it is necessary to fill the stopes with waste rock; this filling is distributed by a light car on a portable track, and is carried up to within 5 to 8 ft. of the roof. Ore chutes or passes are built up by cross-logging through

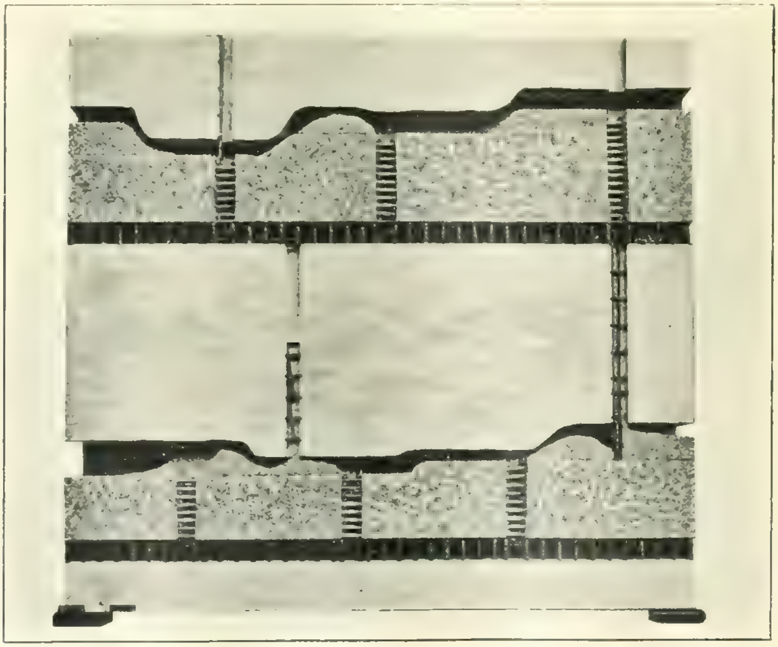


Fig. 1.—Flat Back Stoping.

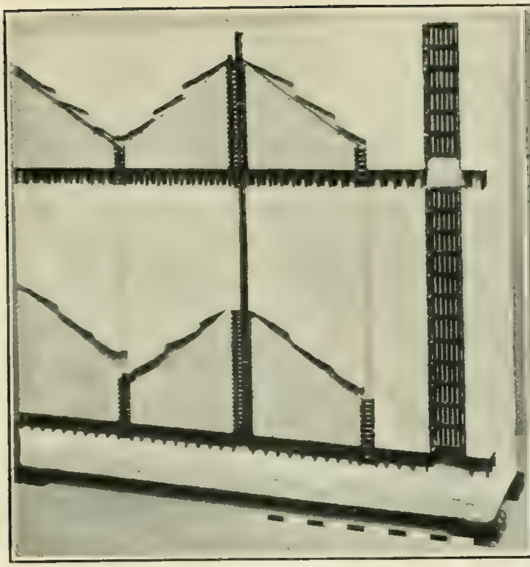


FIG. 2.—RILL STOPING.

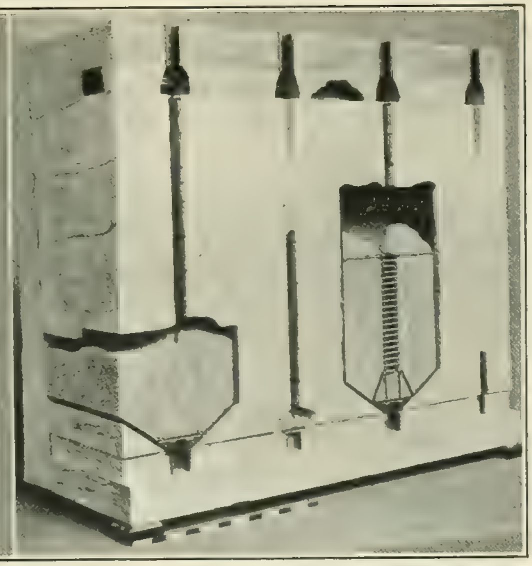


FIG. 3.—GILMAN CUT-AND-FILL SYSTEM.

the waste filling. When waste rock is cheap the method is economical, not more than 5% of the ore being left in the mine. Prospecting work can be carried out from the stopes by means of cross-cuts, etc., and other development work can be carried out more conveniently than from a rill or shrinkage stope. Another advantage of the system is that the rich ore can be sorted out and the ore too poor to pay for treatment can be left behind. The disadvantage of the method, particularly in large stopes, is the cost of transport of the ore to the passes, owing to the shovelling and trucking involved. In some cases this is reduced by the use of wheelbarrows. A corresponding drawback occurs when the stope is being filled, as much shovelling is necessary to distribute the waste rock.

(2) *Rill Stoping.*—This sectional model represents the rill method of stoping-out ore from a vein, a method that is often employed in veins of narrow to medium width, and where filling is needed to support the walls. The name is given to it because the ore gravitates or " rills " in the ore-passes or chutes. Under favourable conditions the ore-body is divided into blocks by levels about 100 ft. apart, and by winzes 50 to 60 ft. distant from one another, but these dimensions will vary according to the character of the deposit. In the model, a section of a portion only of the mine is shown, comprising one of the waste shafts connected with the surface for filling the stoped-out ground. The stopes are worked at angles with the horizontal between 35° and 45°. The flatter angle is that shown in the model. At the steeper angle, should the width of the vein increase, the miner has to exercise considerable caution in moving from the working face. After a slice of ore from 10 to 15 ft. in height has been worked out and taken away, waste rock filling is let down the winze, and if the ore is of high grade, a mat of boards, as shown, is laid on the waste filling to receive the next slice of ore. In the lower stopes the ore is supposed to be of low grade and no timber mat is used. This stope is in the process of being filled with waste rock.

(3) *Gilman Cut-and-Fill System.*—This model shows a method of mining used extensively in Arizona, and, with various adaptations, in stoping the large sulphide ore-bodies found in this and other mining districts of the United States. The method is said to have been named after an American engineer who introduced it. The system consists in blocking out the ore in sections of 40 to 50 ft., with cross-cuts driven from the main drive to the limits of the ore-body on the hanging and foot-wall sides. A section of the stope on the foot-wall side of the drive is represented. Vertical rises are driven upwards from the cross-cuts connected with winzes sunk from the upper level ; later these provide a means of filling the stope with waste rock and serve

for ore chutes and passes. These cross-cuts are the first step in stoping, and the next step consists in widening the ground a little at the side of the cross-cut to permit the temporary timbers to be placed in position. Flooring is laid so as to allow the ore to fall, by removing the short planks, into the trucks below. When sufficient ground has been broken out these temporary sets are replaced by regular timber sets of posts, inclined caps, and vertical sills, with planks to form a mat between the gob of waste rock and the ore below and along either side. After each successive ore-cut from 10 to 12 ft. above the floor, the ore is drawn off, the floors taken up, and the waste rock run in to the desired height. The floor is then relaid to receive the next cut. In the earlier stages of stoping all the ore is not removed as soon as broken down, but is allowed to accumulate as a floor for the miner to stand on. The work at successive stages, numbered 1, 2, 3, and 4, and the method of timbering the workings are shown in the model.

(4) *Top Slicing.*—This sectional model represents a method of extraction used principally in mining large soft ore-bodies. The system is a modification of the long-wall retreating method worked under an artificial roof of timber called a mat. The top of the ore-body is removed either by open stoping or sub-level caving, and a double floor of plank 2 in. thick is laid down. The overburden is then caved-in on top of the mat. A car level is laid out at about 50 ft. below the mat, and the ore is divided by drifts, winzes, and rises into blocks 30 to 40 ft. wide. Commencing at the boundary or walls of the ore, slices 11 ft. in height by 30 to 40 ft. wide are mined beneath the mat, which is supported meanwhile by posts and round unframed caps. As the slicing advances, the timber mat is caved by blasting the posts behind the working face. This method allows a larger and more regular output from the working faces than if square-set timbering is used, but, owing to the rough floor and other conditions, the breaking and shovelling of the ore is not done so economically; the amount of timber used, however, as compared with square sets, is small.

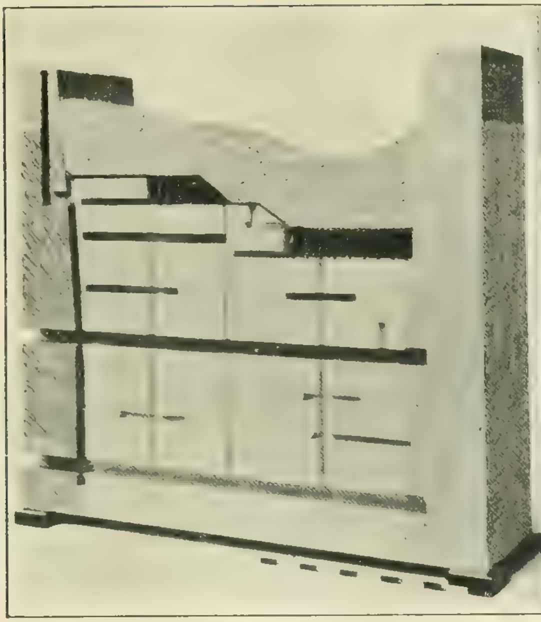
(5) *Ore in Sight.*—This model represents the blocking out of ore in a mine, and illustrates some of the difficulties met with in estimating the quantity of ore in situ. One of the purposes of blocking out the ore in a mine by drifts, winzes, and rises—in addition to the primary one of the work of extraction—is to expose the boundaries of the ore deposit in three dimensions for the purpose of estimating quantities and values contained in the deposit. Owing to the irregular way in which ore deposits occur, such estimates may vary considerably. The Institution of Mining and Metallurgy, recognizing the importance to the mining industry and to the public generally of defining the terms "Ore in Sight," appointed a committee to consider what steps might be taken in the matter. After report and consideration, the Institution made the following recommendations:—

(1) That members of the Institution should not make use of the term "Ore in Sight" in their reports without indicating in the most explicit manner the data upon which the estimate is based; and that it is most desirable that estimates should be illustrated by drawings.

(2) That as the term "Ore in Sight" is frequently used to indicate two separate factors in an estimate, namely: (*a*) Ore blocked out, that is, ore exposed on at least three sides within reasonable distance of each other; and (*b*) ore which may be reasonably assumed to exist though not actually blocked out; these two factors should in all cases be kept distinct, as (*a*) is governed by fixed rules, while (*b*) is dependent upon individual judgment and local experience.

(3) That in making use of the term "Ore in Sight" an engineer should demonstrate that the ore so denominated is capable of being profitably extracted under the working conditions obtaining in the district.

The model illustrates these recommendations. At B B the ore is blocked out on four sides into 50 ft. blocks. At C the ore is blocked out on three sides, but as the top drift is partly in barren ground, owing to the lode not outcropping to the surface, the difficulty of estimation is increased. At D the ore is blocked out on four sides into 100 ft. blocks; at L and T indications of intrusions of barren rock of unknown extent occur. In the case represented, on extraction of the ore, the barren mass was found to be of the shape shown by the dotted line. At E the ore is blocked out on three sides, but no winze has been sunk at Z; the character of the ore at this point, however, may reasonably be assumed from the data supplied by the drifts above and below. The same remark



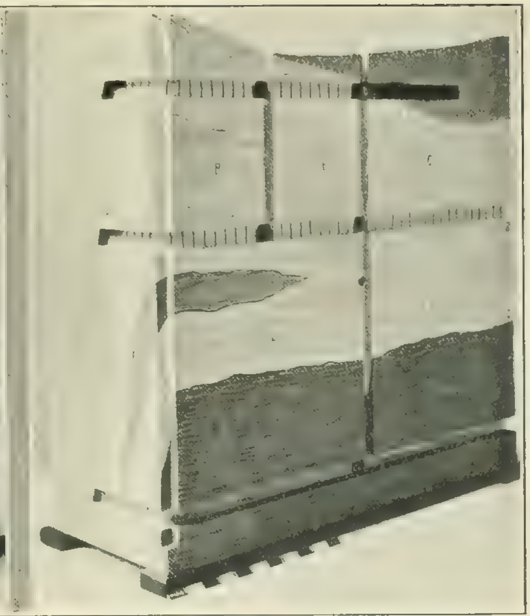


FIG. 4. TOP SLICING.

FIG. 5.—ORE IN SIGHT.

applies to G G. Blue lines on the model every 5 to 10 ft. indicate the points where samples for assaying are taken.

As we have already mentioned, the models described in the foregoing paragraphs are only five out of over thirty made by Mr. Leech. To give an idea of the full scope of his work, we give herewith a list of titles of the others, at the same time expressing regret that space prevents us giving the descriptions and illustrations: Shrinkage stoping; sub-level caving system; milling system of mining; block slicing; mine head frame; prospector's shaft; Australian spaced-box mine shaft; Rand shaft timbering; main adit or level timbering; four-piece level set timbering; four-piece level set for side pressure; stull timbering; angle setting; stull timbering with varying angles of walls; three-piece stull timbering; stull and false stull; stull and saddleback timbering; saddleback stulls with ore chute; reinforced stulls; Chinaman ore chute; timbering level sets with stoping beneath; square-set timbering for stopes on Eureka system; square-set timbering for stopes on Bingham system; square-set timbering for stopes on Burlingame system; square-set timbering with round timber; rock-drill staging; end tipping truck; all-round tipping truck; froth flotation plant; magnetic separator; cyanide plant; etc., etc.

The Institute of Metals

The autumn meeting of the Institute of Metals was held at Birmingham on September 21 and 22. The following papers were read and discussed: The Properties of some Nickel-Aluminium-Copper Alloys, by A. A. Read and R. H. Greaves; The Effect of Increasing Proportions of Lead in the Properties of Admiralty Gun-metal, by R. T. Rolfe; The Casting of Brass Ingots, by R. Genders; The Density of the Zinc-Copper Alloys, by T. G. Bamford; Experiments in the Working and Annealing of Copper, by Dr. F. Johnson; The Effects of Progressive Cold Drawing upon some of the Physical Properties of Low-Tin Bronze, by W. E. Atkins and W. Cartwright; The Extrusion Defect, by R. Genders; The Use of the Scleroscope on Light Specimens of Metals, by F. S. Tritton; The Annealing of Rolled Zinc, by D. H. Ingall; The Constitution and Age-Hardening of the Alloys of Aluminium with Magnesium and Silicon, by D. Hanson and M. L. V. Gayler; The Electrolytic Etching of Metals, by F. Adcock; Electron, the High-Magnesium Alloy, by S. Beckingsale. A number of visits were paid to metallurgical works in the neighbourhood, and there was also an interesting visit to the Birmingham University, where the courses of instruction were intimately studied.

THE CHARACTERISTICS OF CASSITERITE

By E. H. DAVISON, B.Sc., F.G.S.

Many minerals are easily mistaken for cassiterite. The author gives a concise statement dealing with this subject, intended for the guidance of workers in the field.

Cassiterite is a mineral which, owing to its variation in colour and texture, is by no means easy to recognize with certainty. It has, to the writer's knowledge, happened that such minerals as blende, axinite, and zircon, have been mistaken for it by observers with considerable experience. Though its characters are given in detail in Dana's *System of Mineralogy*, and more or less completely in other textbooks (especially well in Collins' *Mineralogy of Cornwall and Devon*), it is felt that the following summary of its physical and optical characters and its chief characteristic chemical reactions may be of use to those who have to deal with tin ores and alluvials. Special reference is made in connexion with other minerals often mistaken for it.

Physical Characteristics.—Cassiterite has a hardness of from 6 to 7 on Mohs' scale; it therefore cannot be scratched by a knife. Its specific gravity varies from 6·8 to 7·1. It has imperfect cleavage, which is often not to be observed, with uneven or subconchoidal fracture, brittle character, and adamantine lustre. Its streak is white to pale buff, and it may be nearly transparent or opaque.

The colour varies from black through brown, red, and yellow, to pale buff or white. The powdered mineral is of a pale buff colour, unless coloured by admixture with iron oxide.

The following varieties are recognized :—

Crystalline cassiterite, "diamond tin," in fair-sized tetragonal crystals in low pyramids or short prisms.

"Sparable tin," in small acute almost acicular tetragonal crystals.

"Rosin tin," reddish or yellowish in colour and translucent.

"Ruby tin," ruby red and nearly transparent.

"Wood tin," brown to buff in colour with a concentric fibrous structure.

"Toad's eye tin," a variety of cassiterite occurring in small spherical masses, with radiating texture, embedded in massive cassiterite of a darker or paler tint.

"Stream tin," in more or less rounded grains or pebbles.

"Black tin" is the miner's term used to indicate tin as tin oxide in whatever form it occurs.

Optical Characteristics.—It is often useful to examine a sample under the microscope in the form of fine powder or as a constituent of a micro-section of a rock or veinstone. When this method is used several minerals are likely to be confused with cassiterite which would be readily detected in the hand specimen.

Colour in transmitted light varies from deep red-brown through pale brown or yellow to colourless.

Cleavage (only occasionally seen) parallel.

Refractive index 1·99 to 2·09, very high relief.

Zoning common and well shown.

Pleochroism none or very feeble.

Polarization colours very high, simple twins common.

Colour in reflected light pale buff or white.

"Wood tin" shows concentric radiating fibres which give a black cross between crossed nicols.

"Wood tin" is seen under the microscope to consist of concentrically arranged crystalline prisms which give the usual birefringence colours between crossed nicols and is in no sense noncrystalline, each individual prism being readily distinguished.

"Toad's eye tin" consists in come cases of quartz crystals zoned by included granules of cassiterite, which are often of extremely minute size.

The characteristic buff colour of cassiterite in reflected light is one of the most distinctive characters under the microscope and of great help in distinguishing cassiterite from minerals with characters otherwise similar.

Blowpipe Reactions.—Heated on charcoal gives a white incrustation which turns blue or blue-green on moistening with cobalt nitrate and reheating. Fused on, charcoal with soda yields a bead of metallic tin as well as incrustation. Potassium cyanide may be used instead of "soda" with advantage.

Chemical Test.—When cassiterite is placed in contact with zinc and hydrochloric acid it

TABLE SHOWING CHARACTERS OF CASSITERITE AND OF MINERALS LIKELY TO BE MISTAKEN FOR IT.

Mineral.	*Sp.Gr.*	*Hardness.*	*Crystal Form.*	*Blowpipe and Chemical Tests.*	*Optical Characters.*
Cassiterite. SnO_2.	6·8–7·1	6–7	Tetragonal pyramids or prisms.	Metallic bead with soda or potass. cyanide on charcoal. Incrustration on charcoal which gives blue-green with cobalt nitrate.	Pleochroism feeble or none. Birefringence very high. Buff or white in reflected light.
Zinc Blende. ZnS.	4·0	3·5	Cubic often in tetrahedrons.	Incrustation on charcoal which gives grass green with cobalt nitrate.	Isotropic. Buff or grey in reflected light.
Ilmenite. $FeOTiO_2$.	4·7	5·5	Tabular trigonal.	Yellow solution with potass. bisulphate turns violet when reduced by tin.	Opaque in transmitted light. Black usually with buff patches of leucoxene in reflected light.
Wolfram. $(FeMn)WO_4$	7·5	5·5	Tabular crystals monoclinic.	Microcosmic bead is deep red. Decomposed by HCl, the solution giving a blue colour when reduced by zinc. Streak, red brown.	Black, or dark red if very thin. Parallel cleavage. Lath-shaped sections.
Rutile. TiO_2.	4·2	6·5	Crystals like cassiterite, often geniculate twins.	Microcosmic bead violet in reducing flame. Fused with potass. bisulphate gives a solution which yields violet colour when reduced by tin.	Brown, red, yellow, or grey. Refractive index 2·9. Birefringence very high. Slightly pleochroic.
Zircon. ZrO_2SiO_2.	4·7	7·5	Prisms with pyramid caps tetragonal.	On heating in bunsen flame brown varieties change to red and smoky varieties to pale green or colourless.	Pleochroism none. Birefringence very high. Black in reflected light.
Tourmaline, Borosilicate of Al, etc.	3·1	7·5	Prisms with pyramid top trigonal.	Gives a transient green flame when heated on Pt. wire with potass. bisulphate, and fluor.	Strongly pleochroic. Maximum absorption when vertical. Birefringence very high.
Garnet. $3R''O,R_2'''O_3,3SiO_2$.	3·7–4	7·5	Dodecahedra. Cubic.	———	Isotropic.
Axinite. Borosilicate of Ca, etc.	3·3	6·5	Flat crystals triclinic.	Intumesces in blowpipe flame.	Strongly pleochroic. Birefringence weak.

becomes coated with a film of metallic tin, and this serves as a very useful test for the mineral, especially in testing alluvial gravels. Place the specimen in a zinc dish and pour on dilute hydrochloric acid. After a few minutes' action remove and wash the specimen. The cassiterite grains or crystals will be coated with grey metallic tin. This reaction gives good results with all varieties of cassiterite, except "wood tin," which requires extra long treatment and must be crushed to a coarse sand.

Minerals likely to be mistaken for Cassiterite.—In the veinstone cassiterite is most likely to be confused with tourmaline, zinc-blende, wolfram, and garnet; in the alluvial gravel with zircon, ilmenite, garnet, rutile, and tourmaline; and under the microscope with tourmaline and zircon.

The table above gives the characteristics of each of these minerals so that they may be readily compared and identified. By use of this table it should be possible to differentiate between the various minerals which on first sight may be taken for cassiterite, and confusion between this mineral and ilmenite and garnet, for instance, should be avoided.

THE GYRO COMPASS FOR SURVEYORS

In the August issue British Patent 18,346 of 1920 was quoted, giving particulars of the gyroscopic compass for surveyors made by Anschütz & Co., of Kiel. Since then the following descriptive article has been sent us by this firm.

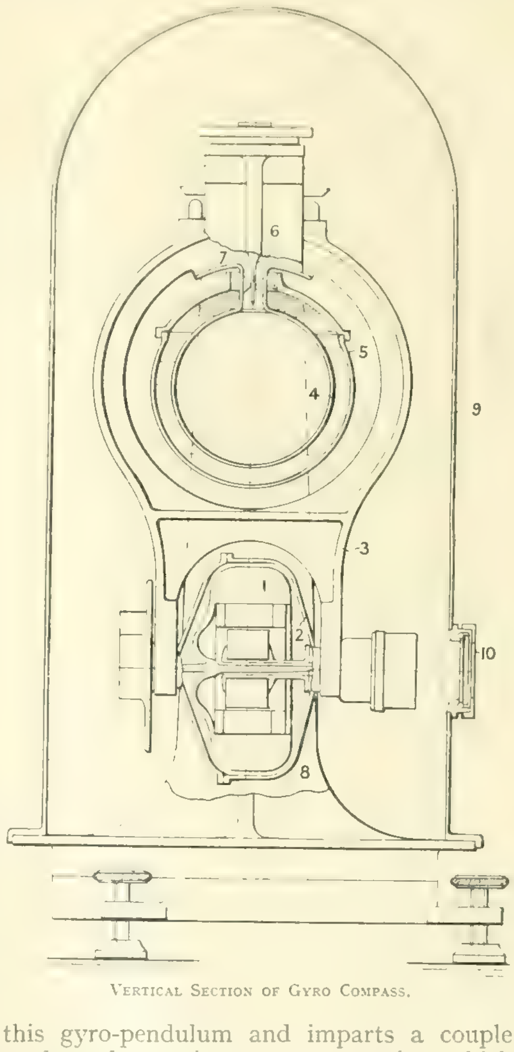
It is known to every mining engineer that the needle underground, especially in rock containing ore, is exposed to so many and complicated disturbances that it becomes almost impossible to get even an approximate indication of the magnetic meridian. The difficulty is so much the greater as there is no means of checking a deviation underground, which above ground can be done by comparing the reading of the compass with the meridian line found by taking terrestrical or or astronomical bearings.

For navigation the unreliable magnetic compass has already given place to a perfect substitute in the non-magnetic gyro compass. This apparatus is an invention of Dr. Anschütz-Kaempfe, of Munich. After more than ten years of persevering investigations and experiments he succeeded in 1908 in designing an apparatus fit for use on board ship, and brought it soon to a high degree of perfection. Others have since appeared on the market employing the same principle.

The design of the gyro compass is founded exclusively on dynamical laws, and the instrument is free from all deficiencies of the magnetic compass without introducing others in their place.

It was desirable to employ this new indicator of direction also for tunnelling and mining purposes, as there really was a great need for a non-magnetic compass in this branch of industry. This idea has long been followed by Anschütz & Co., of Kiel-Neumühlen, and it is due to the technical head of this firm, Dr. Max Schuler, that the investigations in this line were finally crowned by success. A surveying gyro compass has been designed showing true north with such exactness that it fully satisfies the demands of the surveying engineer. The apparatus as built indicates the meridian with an exactness of a half-minute of arc. This exactness may perhaps even be surpassed in future.

Those who are not well acquainted with the latest nautical developments will appreciate a short explanation of the principle of the new compass. In the gyro compass the needle is replaced by a rapidly rotating gyrostat as directive element. This gyrostat spins about a horizontal axis and is suspended in such a manner that the metacentre lies a small distance below the point of suspension. Gravity keeps the axle of such gyrostat horizontal. The earth's rotation acts upon



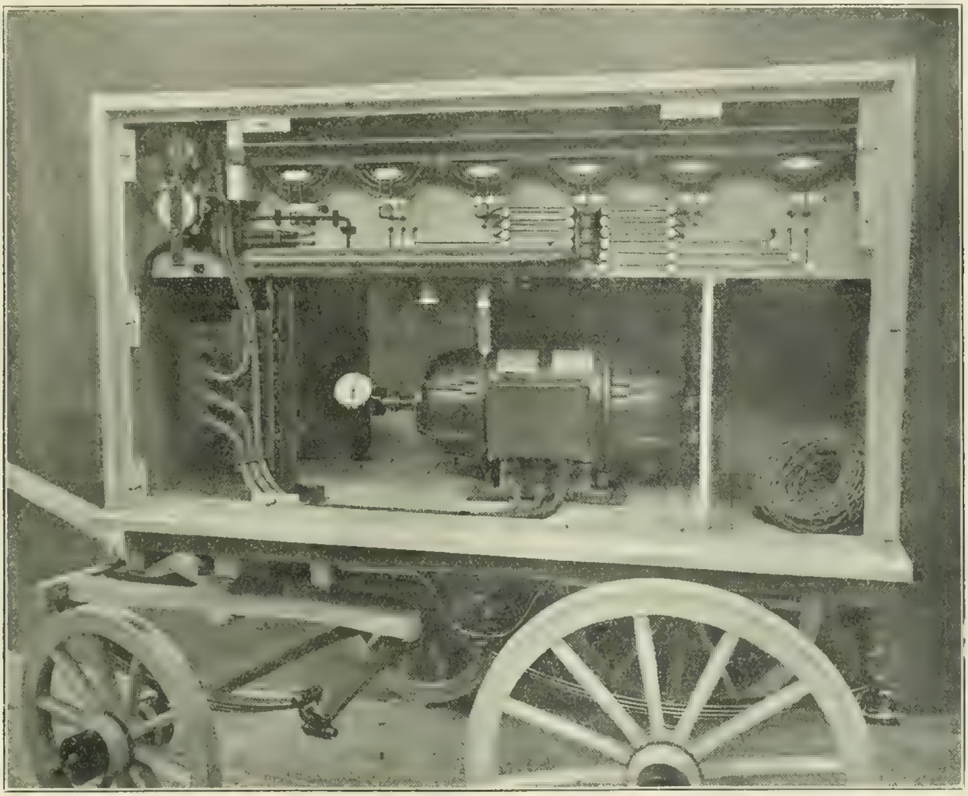
Vertical Section of Gyro Compass.

this gyro-pendulum and imparts a couple to the axle, causing a gyro-precession, which continues until the axle stands in the plane of the meridian.

The suspension of the gyrostat in the Anschütz compass is practically frictionless, being attached to a globular float immersed in a mercury bath. As there is no friction to

reduce the oscillations of the axle while settling into the meridian plane, it does not come to rest, but continues to swing to and fro about the meridian with very slowly decreasing amplitudes. In the case of the gyro compass for navigation it is necessary to fit the gyro system with a damping device to reduce these oscillations. The surveying compass does not require such attachment, as it would only diminish its exactness, and there is no difficulty in reading the true casing can be raised in such a manner that the floating system is fixed rigidly to the supporting bracket (*8*), whereby the upper opening of the mercury cup is closed, and no mercury can spill out of it during the transport.

The fly-wheel with the axle is turned out of one piece of high-class chrome-nickel steel. This is necessary because of the enormous centrifugal force developed, as the gyro spins at a speed of 20,000 revolutions per minute.



Transformer for Generating Current for Gyro Compass.

meridian by taking the average of a few oscillations.

The vertical section indicates the construction of the instrument. The fly-wheel (*1*) is pivoted horizontally in the gyro-casing (*2*), which by a bracket (*3*), is rigidly attached to the hollow globular steel float (*4*) immersed in mercury contained in the mercury cup (*5*). By a centre-pin (*6*), playing in a sharp-edged neck-ring (*7*), the floating system is kept in the middle of the suspension, supported by a bracket (*8*).

In order to make the instrument readily portable the bracket (*3*) with float and gyro- The axle is designed according to the Laval principle, and is pivoted in high-precision ball-bearings, which are lubricated by oil wicks. The gyrostat is designed as a three-phase motor with short-circuited rotor. The rotor is fixed in the bell-shaped fly-wheel. The stator is fixed to the gyro-casing, and encloses the gyro-axle. It is enclosed by the rotor, with very little space between them. The fly-wheel is at the same time the ring of the rotor, which, otherwise, could not resist the enormous centrifugal forces.

The three-phase current driving the gyrostat is generated by a transformer from con-

tinuous to three-phase. The exactness of indication requires a perfectly constant periodicity of the 333-cycle three-phase current; the generator, therefore, must be designed and constructed with special care. For use in mining and tunnelling the generator can be fitted on a cart as shown, which also carries the switches, regulators, fuses, and electric measuring instruments. This carriage can remain in the main gallery, while the compass, connected to it by a cable, is used in a narrow side-gallery.

The three phases of the current are conducted without friction to the gyrostat. Phase 1 passes through centre-pin (*6*) dipping into a few drops of mercury contained in a steel vessel below neck-ring (*7*). Phase 2 goes in the same way through a contact-pin and a second contact-vessel, not shown on the drawing. Phase 3 is in short-circuit with the mercury-cup (*5*) and passes through the mercury to the float (*4*), where it is taken up by an insulated wire.

The whole gyro compass is contained in an air-tight binnacle (*9*) filled with hydrogen. In this way the compass is protected against all disturbances by incompetent or incautious handling, the friction is reduced to a minimum, the consumption of current is considerably diminished, and the rotating parts last longer. The oil greasing the ball-bearings cannot get thick, which, of course, is of great advantage to the security of working. The mercury in the contact-vessels cannot oxidize, because of the complete absence of oxygen. Moreover, dirt and vapour cannot enter the binnacle, which is of importance, as they could become fatal to the inner parts of the apparatus worked with such mathematical precision, especially because in an air-binnacle it would be necessary to cool the gyro by a continuous draught.

The reading of the indication is done through a window (*10*) in the gas-binnacle. For this purpose a mirror reading of the Poggendorf type is employed. The curve of oscillation is traced on millimetre-paper. The average of these oscillations gives a reading of the true meridian with an exactness of half a minute of arc. The mirror is fixed to the gyro-casing in front of the inspection window (*10*). The gyro-casing with mirror can be turned about the axis of the gyro, that is, the centre of the mirror. Without turning the mirror 180° at every reading it would be impossible to test the proper position, if it is desired to keep the errors within the limits of one minute of arc or less. The securing of the mirror to the gyro-casing presents the advantage that any changes of shape of the supporting bracket (*3*) and of the float (*4*) do not affect the reading. This disposition also makes it permissible to leave a little more space between the centre-pin and neck-ring, with the result of reducing friction about the vertical axis.

LETTERS TO THE EDITOR

The Origin of Primary Ore Deposits

The Editor:

SIR—Dr. Morrow Campbell's letter in the September number of the MAGAZINE needs a few observations from me, if you will kindly grant me a little space.

Dr. Campbell says he made no attempt at explaining the well-known features of the different classes of ore-bodies. From the title of his paper alone I submit that most readers would conclude that was the intention. I do not see how the inquiries referred to in the second paragraph of his letter can explain the origin of primary ore deposits if they cannot explain the various forms in which such bodies occur. It is largely in that way that the sufficiency of an idea or a combination of ideas regarding genesis can be tested. Any number of suggestions may be made in the laboratory, but it is only such as fit the facts observed in the mine that can be accepted. It is because Dr. Campbell's suggestions will not explain those facts as put forward in the May number of the MAGAZINE that I say they fail.

As Dr. Campbell has not before him the work of Carl Barus on "Igneous Fusion and Ebullition" (United States Geographical Survey Bulletin 103), I may perhaps be allowed to introduce here a few remarks from that author. On p. 41 he says: "I also made special experiments on the floating of solid rocks on the molten magma. To my surprise, such flotation always occurs, notwithstanding the fact that originally the cold rock must be 10% more dense than the molten rock. It soon appeared, however, that the cause of such flotation is crudely mechanical, since the rock, in virtue of its weight, simultaneously hollows out a cavity and chills it, thus forming a little solid boat on which it floats on the viscous slag below." I think the viscosity of the magma combined

with the reduced density of the newly formed solid are sufficient to account for the flotation of the latter. Barus shows that the molten magma was sufficiently sticky to be drawn out in threads when the temperature of the magma was 250° C. higher than that at which it became solid.

In paragraph 3 of his letter Dr. Campbell says: "That an aqueous mother-liquor is given off by magmas, which, on consolidation, yield granite, is so widely accepted that it seems unreasonable to regard it as anything but a fact." Wide acceptance of ideas does not prove them to be true, or many of the so-called explanations in geology, now discredited, would be still in full favour.

In paragraph 8 Dr. Campbell says: "Mr. Kendall asserts that the basic rocks do not contain free bases with which the free silica in granite could have combined originally." My statement with reference to this matter was the following: "The same sort of argument leads to the conclusion that the basic rocks did not come from a substance having the mineral constitution of diorite. If the free silica of granite was previously combined, what has become of the bases with which it was united. They are not found in the more basic rocks." This is a very different statement from that attributed to me by Dr. Campbell. Later, in this connexion, Dr. Campbell says: "If Mr. Kendall realizes that the bases in calcium carbonate and sodium chloride, as well as magnetite, were originally combined with silica, he will probably admit that the conclusion he has arrived at on this subject is not at all a safe one." I do realize that the bases of the first two of these substances were originally combined with silica, but I also realize that their separation from that mineral was not effected until long after the differentiation and consolidation of the magma from which the silicates originated. That subsequent to the formation of the various plutonic rocks, and their appearance at the earth's surface, the felspars, amphiboles, and pyroxenes—largely composing those rocks—were subjected to decomposition and severe denudation. It was then that the calcium and sodium Dr. Campbell refers to were liberated, as well as the substances forming the argillaceous and siliceous rocks, which form such a large part of the earth's crust. But neither the salt in the oceans, nor the lime in the calcareous rocks have anything to do with the appearance of free silica in the granite.

I need not further remark on the difference between Dr. Campbell's definition of a primary ore and that suggested by me, beyond saying that Dr. Campbell bases on a highly disputable hypothesis, while I follow the results of visual and other direct observations.

Dr. Campbell's remarks about the Leadville ores are too general to deal with, but it may be stated that there are both primary and secondary ores in those mines. It would be interesting if Dr. Campbell would describe in detail the most important of the "many galena and other sulphide ores that he regards as not primary but secondary," and explain how they were derived from primary ores.

J. D. Kendall.

London, *September* 23.

The Real Value of Gold

The Editor:

Sir—I read with interest Mr. Speak's article on this all-important question. He approaches and discusses the question of the real value of gold partly from the point of view of the gold-producer and partly from what we may call the view of the wire-puller. I am desirous of making some observations on this subject from the point of view of the relation of the productive effort of human beings, as expressed in goods, commodities, and things, to the purchasing value of currency.

Firstly, the real value of gold is what we human beings make it, either considered in the sense of it being a commodity or in the sense of its function as currency; this self-evident fact I expect all admit.

Secondly, gold is, for the purposes of currency, given a standard or fixed value, which, among other things, enables variations in the efficiency methods and productive effort of us human beings, considered either collectively or individually, to be noted, regulated, and controlled.

For instance, making gold some fixed standard value, and issuing currency tokens based on this fixed value, serves the same purpose in one sphere of human activity in exchange of goods, commodities, things, and services as does the fixing of a standard lb. weight for measuring quantities or a standard foot for measuring lengths or distances.

Mr. Speak suggests that the value of gold should be increased approximately 50%, as the best solution for overcoming our present troubles and the general state of

depression and unrest now existing. It seems to me he overlooks several important factors and their real significance and influence on controlling and regulating the actual purchasing value of currency either in goods and commodities or in determining the amount that can be paid for services rendered in the performance of particular classes of work.

What is implied in this statement will be better understood from an appreciation of the remarks that follow.

If the real value, or a new standard value for gold, is fixed at, say, 50% above the pre-war gold standard, the resultant effect will be that the amount of gold that is supposed to represent the value of a one-pound currency note will be 50% less than before. The purchasing value of a pound note will fall just by this amount, simply because its purchasing value is ultimately determined by the goods, commodities, and things we human beings are able to obtain in exchange for the pound sterling.

Human beings determine the exchange value of commodities, not money, in actual fact.

Money or currency, after all, if we work right back to first causes, is only the lubricant whereby human effort and human activity is scientifically directed to produce goods, commodities, and things at maximum capacity with least inconvenience, so that the individual secures the results of his effort in producing goods and in services rendered in the easiest and most convenient way.

Next, if the standard value of gold is increased 50% artificially by a Government decree, through pressure brought to bear by wire-pullers, then what will happen will be that American wheat will advance in price in terms of our currency 50%. Our quartern loaf of bread, instead of costing us as now 1s., would cost 1s. 6d. ; an ounce of tobacco would cost not 1s. as now, but 1s. 6d. ; meat and everything else would go up in proportion ; and the only remedy for us would be to raise wages of workmen 50% in harmony, and likewise salaries and emoluments of all other workers. In other words the ball of inflation would be set rolling full force all over again.

Does Mr. Speak really believe the copper producer will be content to sell his copper for, say, £70 per ton as at present when the standard value of gold is increased in price 50%, and the fractional part of an ounce of gold that is taken to represent a pound sterling is reduced by 50% ?

The producer will probably agree to exchange the same amount of copper for the same equivalent amount of gold as at present, but not for the same equivalent number of currency notes as at present ; that is where the rub comes in ! Producers of all other commodities would do exactly the same. If this much is not conceded, then why not change the standard lb. weight and call the new standard lb. that weight which is represented by 1½ lb. to-day ?

Of course, everyone knows what the resultant effect would be if this were done. It would first of all create chaotic conditions, and secondly it would make absolutely no difference to the actual quantity of wheat, meat, tobacco, or anything else, we could obtain from producers in exchange for currency. That is, it would not improve the purchasing value of currency. What would apply if the standard lb. weight were altered would apply equally if the amount of gold that represents a pound note were altered.

No, it is the law of supply and demand that is at work and in operation which is causing prices for goods and commodities and wages paid for services to gradually fall and tumble, or, in other words, deflation is being forced upon us as a nation, because other nations are producing the same goods and commodities we produce and export at less cost and paying lower wages for services than we are.

In order to compete and retain our foreign trade and markets we are being forced to scale down our prices.

If England is to meet the new conditions that confront her we as a nation of people must : (1) Reduce the burdens of taxation falling on the people and on industry, that is, State expenditure and extravagance should be curtailed ; (2) improve our efficiency methods in all spheres of human activity ; (3) Increase the amount of our productive effort while at work. The coal miner should strive to increase the output of coal per month per man employed, and the same applies to the working man in all other trades and industries.

If all three of the above factors are made to work in harmony, then the purchasing value of a pound sterling will increase, and a state of prosperity return to trade and the people of England.

It seems to me to be the duty of our Government to adopt every legitimate means in their power to try and bring about deflation, because the real cause of our trade

slump and the depression that exists in the country is due to external pressure ; that is, other nations are encroaching on, and entering our markets at home and abroad, underselling and outbidding us as traders.

The index whereby we are able to judge of the actual position of affairs is by noting what the purchasing value of our pound sterling is now, compared with its purchasing value in pre-war days.

What real difference will it make to a producer of goods if, say, to-day he produces 10,000 things for £1,000, and owing to falling prices he is only able to realize £800 on them, if he is still able to produce a like number of the same things to-morrow for the £800 received for the others ?

Again, if £500 will purchase in five years time what £1,000 purchases to-day, what difference does it make to any person then if they only receive £500 in exchange for their £1,000 ? The purchasing value of both are equal, everyone loses nothing in reality, the only difference being that £1 in five years would go as far in purchasing goods, commodities, and services as £2 to-day.

This, then, gives another side of the picture approached from a different point of view on the subject of the real value of gold, and rather points to the fact that deflation would if carried to its logical practical conclusion establish a stable currency which would enable the trade and commerce of the country to revive rapidly.

Gold considered as a commodity is not discussed here, as it would make this reply too long, but stated shortly, fluctuating exchange rates between nations, due to fluctuating trade balances, automatically determine the real value of gold as a commodity ; or, stated in other words, markets (the supply and demand for gold) prove in practice stronger than legislation.

It has, as a matter of fact, always seemed to me in thinking about the real function of money or currency that the Jews understand the significance and meaning of the elementary truths enumerated above better than we do, and I advance it as a probable reason why they are the world's greatest financiers and likewise why so many of them are numbered among the world's greatest philanthropists.

H. C. Bayldon.

London,
September 16.

BOOK REVIEWS

Mine Rescue Work and Organization. By H. F. Bulman and Frederick P. Mills. Cloth, octavo, 182 pages, illustrated. Price 12s. net. London : Crosby Lockwood & Son.

There are employed in mining operations throughout the world over six million persons, and of these there are engaged in the working of coal more than the combined totals of all those engaged in other classes of mining, such as exploitation of ores of iron, copper, gold, non-metallic minerals, etc. The value of rescue apparatus at collieries has become so generally recognized that in the principal coal-mining areas Government regulations demand that self-contained breathing appliances be available for use if required at the mine. Accidental ignitions of timber or explosives in metalliferous mines may produce conditions akin to those which exist when an explosion or underground fire occurs at a colliery, and it may be said that the useful application of mine-rescue apparatus is likely to extend far beyond the circles for which it was primarily designed. A committee appointed on the suggestion of the Home Office to investigate the types of breathing apparatus used in coal mines under the chairmanship of Mr. William Walker, the Chief Inspector of Mines, suggested in 1918 that the question of applying the rescue regulations to mines under the Metalliferous Mines Regulation Act should be taken into consideration when any new legislation relating to these mines is introduced. On two occasions the Cumberland rescue station has been called upon for assistance at iron ore mines, and a colliery brigade saved the life of one man gassed by carbon monoxide. For nearly ten years at the examinations for certificates of competency as colliery managers there have been always placed before the candidates questions on rescue work, a subject of growing importance.

Students and others who have to deal with the subject under discussion will find the work of Messrs. Bulman and Mills a helpful publication. The Government regulations on the provision of apparatus at mines and at rescue stations and the course of training for rescue brigades are explained in detail.

It is useful for central rescue stations in the British coalfields to serve a number of collieries situated at a distance of not more than 10 miles in direct line from each station.

At these centres there are provided special facilities for the training of teams from each colliery, which has thus available, in case of accident, men well acquainted with underground conditions at the mine. Their efforts in dealing with an accident would be supplemented by assistance from the central station which is organized on the principles of a fire brigade for prompt turn out when required.

The course of training suggested by the authors is apparently based on practical experience and has doubtless given excellent results, but in the course of fourteen lessons for teams sent from collieries for training there seem to be several points open to criticism. The men are asked to see that provision is made at their collieries for telephonic communications, suitable road for motor fire engine, and good foundation for engine, etc. Details are given of weight and dimensions of motor pump, and it is pointed out that hydrants and hose should be inspected weekly. Would not an official communication from the central mine rescue and fire brigade station direct to the manager of the mine be a better method of dealing with matters of this character, than placing them in the hands of half a dozen men whose primary object in attending the course of instruction is to make them capable of acting efficiently in an irrespirable atmosphere?

The various types of respiratory apparatus and accessory appliances are well described, but no information is given of the Meco apparatus, and the geophone, of which there is a detailed account, does not appear to be of the type familiar to a large number of mining engineers who had experience with Tunnelling Companies of the Royal Engineers during the late war. This instrument, described by Major Standish Ball in the Proceedings of the Institution of Mining and Metallurgy, 1919, not only magnified any sound passing through solid rock but indicated with great accuracy the direction of point of origin. A brief account of the method of utilizing the geophone underground would add to the value of the book under review.

That aeroplanes will be utilized "sooner or later" for the transport of men and apparatus from rescue station to a mine on occasion of disaster, as suggested by the authors, appears to be very doubtful. The difficulty of obtaining a suitable landing place, "an area of 75 acres" near to the mine as mentioned, is not the only factor to be considered under present requirements. When there is an urgent call for assistance a motor-car would be far superior to an aeroplane in quickly reaching a mine within 10 miles of a rescue station.

The authors show a sound and practical knowledge of their subject, and as a text-book, *Mine Rescue Work and Organization* may be recommended to the attention of the mining community.

STANLEY NETTLETON.

Problems in Land and Mine Surveying. By DANIEL DAVIES. Second edition. Cloth, octavo, 355 pages, illustrated. Price 12s. 6d. net. London: Charles Griffin & Co., Ltd.

Civil engineers are fairly well supplied with manuals on surveying applicable to their work; mining engineers are not. The really good all-round book on mine surveying has still to be written; it will be received with open arms when it is. While awaiting its tardy arrival we must be grateful to those authors who present us with treatises covering some of the ground in a helpful way, as is the case here. The first edition, reviewed in these columns in July, 1918, had 276 pages, 145 diagrams, and 400 questions, of which 291 were worked out. The second edition has 355 pages, 195 diagrams, and 550 questions, of which 350 are worked out. Several minor corrections have been made, and the scope of the book has been advantageously extended. Many of the problems and diagrams were originally published in *The Science and Art of Mining*, a periodical well known to students of coal mining; and the book is intended principally to assist the young colliery engineer. The most numerous problems given are those involving calculation of areas, use of trigonometrical ratios, and mensuration, with many others dealing with amount and direction of dip, co-ordinates, errors, faults, levelling, scales, etc. Noticeable additions are: loose needle surveying in the presence of iron, azimuth by solar observation, conventional signs in plan-making, operation of levelling with a dumpy level, methods of booking levelling notes, and a dial survey of a steeply inclined shaft and drift with plan and section plotted therefrom.

For obtaining areas by co-ordinates the author uses the rule: multiply the total latitude of each station by the algebraic sum of the departure of that traverse or

draft and the one following; the sum of these products divided by two is equal to the area of the closed traverse. From the professional standpoint a better rule is: multiply the algebraic sums of the total latitudes (or departures) of every two adjoining stations by the algebraic differences of the total departures (or latitudes) of the same stations; the algebraic sum of the products is double the area. The solar observation example has no explanation appended to it, making it difficult of comprehension by a student; moreover, decimals of seconds are quite superfluous in an observation which usually is not expected to give the true azimuth at best nearer than to 1 minute, and the inadvertent insertion of the declination instead of the codeclination value in one part of the calculation makes it puzzling to the uninitiated.

Approval must be accorded to the instruction that "bordering should be neat, but not unduly elaborate; otherwise appreciation of a well-executed plan may be lost in admiration of the border." Still, students like to spread themselves a bit in the matter of embellishments when it comes to titles, north points, and borders; and enthusiasm for artistic draughtsmanship, even of a rather florid type, is not a bad sign, and should not be too severely repressed.

The book is pleasantly produced, and, within its scope, should be most helpful to students; it should also be of assistance to teachers in furnishing them with a collection of worked and unworked problems suitable for class exercises.

ALEX. RICHARDSON.

Field Mapping for the Oil Geologist. By C. A. WARNER. Cloth, octavo, 145 pages, illustrated. Price 13s. 6d. net. New York: John Wiley & Sons. London: Chapman & Hall, Ltd.

The rapid growth of the petroleum industry has brought with it a corresponding increase in the amount of technical literature dealing with all matters pertaining to oil finding, and the last nine months especially have seen the production of many useful volumes in this connexion, mainly from America. As not unfrequently happens, however, such a literary boom brings with it certain publications which are neither up to the standard of excellence nor of the specific value of contemporary works, and at the outset we are bound to say that this little volum suffeers in these respects.

Firstly, it is somewhat overshadowed by the recent volume by Cox, Dake, and Muilenburg on "Field Methods in Petroleum Geology," reviewed in the June number of the MAGAZINE, which covers practically the same ground, though in much more detail; secondly, as an exposition of field methods, even simply as an outline of first principles, it is sadly inadequate, since much that is of fundamental importance in geological mapping and subsequent interpretation of structures is omitted. Further, the general foundation of the subject which the author sets out to construct is unfortunately made unsafe by extreme brevity of treatment, and without some previous knowledge and experience by way of supplement, it is rather doubtful whether a mere perusal of this work would afford the reader the requisite theoretical grounding in his subject.

The text consists of 145 pages, of which roughly 63 are taken up with tables of constants, geological fundamentals, and index, thus leaving only 82 pages in which to dispose of the subject matter; the latter is dealt with under five chapters, the first being a study of field conditions, the second dealing with maps, their value and interpretation, the third discussing field-mapping and methods, the fourth, mapping instruments, and the last containing details of meridian determination and the tables above referred to. With regard to the first chapter there is little to remark beyond the fact that a discussion of such a broad phase of the subject, when limited to seven pages, cannot possibly be more than the barest summary; for instance, the author might well have extended his remarks on oil-seeps and their examination; far too great importance is, we fear, paid to surface indications of petroleum, so frequently suggesting escape of oil rather than storage in subterranean pools. In Chapter II the study of geological and topographical maps is somewhat stereotyped, as are the illustrations which include the inevitable landscape and contour map reproduced from the inside cover of the United States Geological Survey folios; this particular illustration seems to be a *sine qua non* in American literature of structural geology, as is the case with several other illustrations repeated from time to time in different volumes; such reiteration suggests lack of imagination and does not tend to the creation of a well individualized work.

In the third chapter on field mapping and methods, the author embodies the results of personal experience in geological surveying, and although brief, much useful information is offered. The remarks on correlation of unfossiliferous strata, however, are unfortunate, since the use of vertical sections, implying uniformity of conditions over wide areas, must be extremely limited, uniformity being the exception rather than the rule in most countries. No mention is made of petrographic methods of correlation under such circumstances, methods which are far safer than those dependent on mere lithology and which might well be applied to the Red Beds mentioned by the author. The chapter also includes an abstract of Griswold and Munn's paper on certain oilfields which illustrate the working of isochore maps (U.S.G.S., Bull. 318), and concludes with a few hints on writing geological reports; we are glad to note in the latter connexion that the author insists on a degree of brevity commensurate with the amount and importance of the information to be submitted; professional reports so frequently present the appearance of small textbooks that the advice is particularly apposite.

The remainder of the volume is devoted to a discussion of certain instruments used during preliminary survey, and includes information on the telescopic alidade, Brunton pocket transit, and aneroid barometer, followed by notes on meridian determination and various reference tables. The book will, we think, probably make its greatest appeal to American geologists and others engaged in oil-production in that country, since its teaching is based almost entirely on American practice; even if its scope were wider, it is doubtful whether in its present size and form it would command a ready sale in this country at the prohibitive price at which it is published.

H. B. Milner.

Mechanical Drawing. By John E. Jagger. Third edition, cloth, quarto, 251 pages, illustrated. Price 15s. net. London: Charles Griffin & Co., Ltd.

The object of this book, the result of many years of practice and study, is to provide notes, observations, and examples to enable a student to learn how to read drawings, make a simple working drawing, and apply the knowledge gained in his future work. It is intended for students who have not the opportunity to serve in a drawing office, but who should know something of office processes and methods. The ability to read a machine drawing correctly, and to infer considerations not actually expressed in line and curve, is for the mechanical engineer just as important as the ability to analyse a mine plan is for the mining engineer, and no pains should be spared to acquire such facility.

Beginning with instructions on draughtsmanship, the author goes on to tracing, photo-copying, and principles of projection. Then follow a series of dimensioned designs, ranging from a simple cast-iron bracket to a tool-holder for a planing machine, and a chapter on materials used in mechanical engineering. In addition to the numerous illustrations, the book contains much textual information, comprising formulæ, tables, descriptions, and examples for working. It is, therefore, a great deal more than a book on drawing only; and one which engineering students will undoubtedly find useful. By way of suggestion, it might be an increase to utility to include an example of a small lay-out, say, a motor driving a line-shaft from which power was taken off for a few machine tools, for the purpose of leading the student up to the important field of general planning and organization.

Pumping by Compressed Air. By Edmund M. Ivens. Second edition. Cloth, octavo, 266 pages, illustrated. Price 22s. New York: John Wiley & Son; London: Chapman & Hall, Ltd.

Mr. Ivens undertook the study of this subject in the first instance with a view to obtaining information for his own needs. He had the opportunity to install and test a number of air-lifts operating under varied conditions, and thought the data he had gathered as the outcome of his experience and reading were of sufficient interest to condense and publish. To the first edition have been added some thirty pages of text, and several illustrations, formulæ, and tables; the added matter consisting chiefly of operative results.

The first of the fourteen chapters deals with pumping by the action of pistons; the second, with the displacement pump; the third, with the return air system; the next five with the air-lift; the following four with compression generalities, compressor efficiency, compressors, and flow of air in pipes; the thirteenth with the flow of water in pipes; and the last with a

description of a water-works pumping installation. As will be seen, the air-lift, which is by far the most common method of pumping by compressed air, comes in for extended notice. Mining men will be interested in the system of working sulphur deposits developed by Mr. Herman Frasch. The sulphur is liquefied either by melting or by dissolving, and pumped up into settling tanks. The well is cased to a short distance below the junction of the overlying strata with the sulphur bed, and through this the air-lift piping is carried down well into the bed. Steam is admitted into the casing, and melts the sulphur. The mixture of molten sulphur, hot water, and steam is then pumped to the surface. With regard to air-lifts in general, it might be well to bear in mind the author's opinion that "an air lift improperly designed and installed is one of the most criminally wasteful means of pumping known."

The book is well supplied with illustrations, and data, both theoretical and practical, valuable to anyone desiring information on the subject of pumping by compressed air.

☞ Copies of the books, etc., mentioned under the heading "Book Reviews" can be obtained through the Technical Bookshop of *The Mining Magazine*, 724, Salisbury House, London Wall, London, E.C. 2.

NEWS LETTERS

TORONTO

September 12.

METALLIC PRODUCTION OF ONTARIO.—The returns of the Ontario Department of Mines for the first six months of 1921 show a marked decline in the value of the metalliferous output of the province, with the exception of gold and lead. The total value was $11,363,652, as compared with $22,101,580 during the corresponding period of the previous year. In common with other industries mining is experiencing the effects of a poor market, and the general lowering of commodity prices. The output of gold shows a slight increase, being valued at $5,761,504, as compared with $5,690,504, while the production of silver has declined in quantity from 4,474,322 oz. of the value of $5,077,028 to 4,277,762 oz. valued at $2,552,125. The production of the precious metals was much curtailed during the first quarter of the year by the shortage of electric power, and the output of gold for the full year now that conditions are more favourable promises to establish a new high record.

PORCUPINE.—An interim report of the Hollinger Consolidated, covering the first seven months of the year, presents a highly satisfactory showing. The net profit for the period was $2,339,921, as compared with $2,074,025 for the corresponding period of 1920. The total income was $5,125,050, as against $4,012,242, and the total expenditure $2,785,129, as compared with $1,938,218. The average tonnage milled per day was 2,406 tons, as compared with 1,906, and the number of men employed had increased from 1,103 to 1,369.

The Dome Mines is carrying out an extensive plan of exploration to ascertain the extent of the large ore-body encountered on the 10th level, which has been found to continue downwards for more than 300 ft. The workings are being deepened, but it has not been decided how far the shaft will be put down. A new ore-body has been found on the 7th level, but whether it is an upward extension of the deposit on the lower levels has not been determined. According to an official statement the Dome is now treating an average of 840 tons daily, with an approximate recovery of $6·17 per ton.

The assets of the Davidson Consolidated have been taken over by a new company, known as the Porcupine Davidson Gold Mines, in which British capital represented by Sir Archibald Mitchelson and John Hambly, is largely interested, capitalized at £1,000,000 sterling. The amount paid was £175,000 preferred stock and £450,000 common stock, in the new company, and £50,000 cash, shareholders of the old company retaining their securities. A sum of £200,000 is set apart for working capital and the mine is now being unwatered preliminary to the resumption of operations.

The annual report of the McIntyre Porcupine for the year ended June 30 shows total net earnings amounting to $1,088,513, as compared with $1,280,232, and a net profit transferred to surplus of $815,530, as compared with $818,020. The ore produced was 171,916 tons, of a gross value of $2,005,672, averaging $11·67 per ton, as compared with 188,835 tons of $2,175,891 gross value, and $11·52 average value for the preceding year. The ore reserves were estimated at 624,422 tons, of the value of $6,392,394, an increase of nearly $800,000.

At the Beaumont, formerly the North Davidson, the ore-body cut on the 150 ft. level has been tapped by a cross-cut at the 300 ft. level, and is being opened up.

The Porcupine area is being considerably extended by operations which are being actively carried on in the outlying districts where many new properties are being developed. These include the Union Mining Corporation and Daly claims lying west of the producing area; the Big Dyke, Ankerite Extension, Porcupine Paymaster, and March Gold toward the south; Allied Porcupine and Porcupine-Keora to the north-east; Gold Island lying east and the Triplex in a south-easterly direction.

KIRKLAND LAKE.—This camp is rapidly increasing in extent and importance, and has recently experienced a considerable growth in population. The production of the Lake Shore for July amounted to $49,155 from the treatment of 1,967 tons of ore, with an average recovery of $24·99 per ton. President Harry Oakes states that the physical condition of the mine is stronger than ever, and that the capacity of the mill has been increased to nearly 70 tons per day. Structural work on the new mill of the Ontario-Kirkland of 100 ton capacity is nearly completed, and it is hoped to have it in operation by the end of the year. A considerable quantity of ore averaging about $15 is in readiness for milling. At the King Kirkland another new vein has been opened up with a pay-streak from 1 to 2 ft. wide, which shows commercial ore on the surface for 200 ft. Camp buildings are being erected on the Queen Lebel, and a plan of exploration and development has been arranged. A vein system of some importance has been found on the surface at the Lebel Lode yielding high assays. Exploration is being undertaken to ascertain the zone of greatest enrichment before putting down a shaft.

COBALT.—The silver-mining industry continues quiet. Economic conditions have improved, though not sufficiently to induce the producing mines which closed down last year to resume work. Production by the Nipissing mine, however, shows a steady increase, a noticeable feature being the amount of cobalt produced as a by-product. During July ore was mined of an estimated net value of $166,363, including cobalt valued at $25,380, and bullion from Nipissing and customs ore was shipped of an estimated net value of $223,057. At the Violet property of the La Rose Consolidated a vein 9 in. wide, carrying high-grade ore, was struck on the 570 ft. level. On being followed it was found to widen out considerably, and to show greater enrichment. A rich vein has been encountered on the O'Brien adjoining, heading towards the Violet. A vein opened up on the 4th sub-level of the Bailey Cobalt shows 2 to 4 in. of high-grade ore, with good silver contents in the wall-rock. The report of the Timiskaming for a period of 18 months ended June 30 shows net production of the value of $179,294, and other income of $51,479, making a total of $220,773. Operating costs and other charges were $366,539, making a deficit of $135,765.

SUDBURY.—The mines and smelter of the International Nickel Co., in the Sudbury district, as well as the refinery at Port Colborne, Ontario, were closed down for an indefinite period on September 1. Operations had been greatly curtailed for some months, and the suspension was not unexpected. The reason assigned was general business depression, and the accumulation of heavy stocks for which a market could not be found. During the war upwards of 2,500 men found employment at the mines and works, but the pay-roll has since been gradually reduced to about 600. The Mond Nickel Co. is now the only one in operation, and it is only working on a very limited scale.

VANCOUVER, B.C.

COMPLEX LEAD-ZINC ORES. — What is likely to be the most far-reaching event of the month is the bonding of the Stemwinder mine and the Ontario group, at Kimberley, from the MacKenzie & Mann interests by the Federal Mining & Smelting Co., a subsidiary of the American Smelting & Refining Co. No details of the terms of the bond have been announced except that ample time has been given to explore the deposits with a diamond-drill. The Federal company had the Stemwinder property under option in 1918, but relinquished the option after doing considerable drilling. It is easy to see that there are a number of conditions that may have attracted the Federal back to the property. In the first place, with lead and zinc prices about half of what they were in 1918, and with money considerably tighter, it is likely that the company has been able to make better terms with the MacKenzie & Mann interests, a concern that has the reputation in this province as being rather grasping; but what may have weighed more than this with the Federal is the splendid development of the Consolidated Mining & Smelting Co.'s Sullivan mine, which

adjoins the Stemwinder, and the fact that the Consolidated company, after spending some three-quarters of a million dollars in experiments, has solved the metallurgical difficulties in connexion with the exceedingly complex ores found in the Sullivan and Stemwinder mines. This ore is a compact sulphide containing galena, zinc-blende, marmatite, pyrrhotite, pyrite, and small quantities of several other minerals and not more than 6% of gangue. The lead and zinc contents vary in different parts of the mines, but at the Sullivan they average in the neighbourhood of 18% zinc and 12% lead, with a low silver content, probably less than 4 oz. per ton. Besides numerous laboratory plants, the Consolidated built and dismantled several commercial plants—the largest had a daily capacity of 600 tons—before a satisfactory process was devised. The following is a bare outline of the process finally adopted and now in use. The ore is ground to about 20 mesh and tabled to remove some of the galena and some of the gangue ; the tailing from the tables is slimed to 200 mesh, and treated in Minerals Separation cells, a mixture of pine oil and creosote being used as a frothing agent. This gives a concentrate containing the bulk of the lead and zinc sulphides, together with a considerable proportion of iron sulphides and small quantities of other sulphides. The tailing from this process consists essentially of pyrrhotite and pyrite and gangue. The concentrate is roasted, and the calcine is subjected to an exceedingly clever, though very complicated process, in which the zinc oxide is dissolved by acid zinc sulphate solution, and the solution is neutralized and the iron, arsenic, and antimony salts precipitated by zinc oxide in a fresh portion of calcine. The solution is then separated from the residue, and is further purified by agitation with atomized zinc, which removes copper and cadmium, and is then passed through a series of electrolysing vats, where about 60% of the zinc is precipitated on the cathodes. The solution, which has become acid once again, is used to dissolve zinc from a fresh portion of calcine. Thus a continuous circuit is maintained, a little chloride being kept in the circuit to precipitate any silver that may have gone into solution. The residue from this process, which consists essentially of lead sulphate, ferric oxide, and undissolved zinc in a complicated form, largely ferrate, goes to the lead smelter, where the lead and silver are recovered. The Consolidated company will give out no details either as to cost or recovery, but one can make a shrewd guess at the latter from the quantity of ore treated and the zinc produced, and it is doubtful if a great deal more than 60% of the zinc content of the ore is being recovered. The lead recovery is much higher. Low as the zinc recovery would seem to be, there is little doubt about the process being a financial success, as last year the Sullivan mine produced more than 90% of the zinc and nearly 70% of the lead outputs of Canada. Improvements are being made to the process from time to time and undoubtedly a much better extraction ultimately will be obtained.

To return to the Federal company, however, the proving up of several million tons of this class of ore in the Sullivan mine and the development of a process to treat it has probably been the principal drawing card to induce the company to re-enter the East Kootenay field. The opportunities of the Canadian lead and zinc market, which at the present time is almost entirely in the hands of the Consolidated company, probably also has added weight to the Federal company's decision. It is stated that if it receives encouragement in its exploratory work the Federal company is prepared to spend $3,000,000 in the development of the property. Drilling has been started and will be carried on until a definite conclusion as to the value of the ore deposit is reached.

Salmon River District.—An event of considerable importance has been the shipment of the first consignment of concentrate from the Premier mine, in the Salmon River district. The concentrate was obtained mainly from the treatment of cullings of ore that already had been shipped. The consignment consisted of 160 tons, valued at $1,750 per ton in gold and silver, giving it a total value of about $280,000. This practically establishes the Premier as the biggest gold and silver mine in the Province. A large body of ore has been developed, and it is stated that the ore-body has been proved by diamond-drilling to a depth of 600 ft. below the lowest workings. Shipments of both high-grade ore and concentrate will be made continuously as soon as the aerial tramway, now in course of construction, from the mine to tide-water, a distance of 11½ miles, has been completed. In the meantime, concentrate will be shipped by road, as in the present instance, and it is probable that the high-grade will be sacked and held ; though

it is possible, if the tramway is not finished and the travel is good, some high grade will be shipped over the snow during the winter.

The Salmon River district seems likely to fulfil its early promises. At least two, and possibly three, other mines will be shipping from the district during this winter. The Fish Creek Mining Co., which has been developing a promising lode on Fish Creek, a tributary of the Salmon River on the Alaskan side of the international boundary, already has made a shipment of some 20 tons of high-grade ore, which it is expected will give a return of between five and six hundred dollars per ton, and the company has some 100 tons of similar ore mined. This ore is being held until better shipping facilities are available. The Alaskan Government is building a good trail to the mine, and by the time this has been completed it is expected that the property will be sufficiently developed to be in a position to make regular shipments. Up to the present all the ore that has been taken out has been mined from open-cuts, but a tunnel is being driven to cut the ore-body at a depth of 50 ft. below the outcrop, and this will give cover for operations during the winter. A permanent camp has been established, and work will be continued steadily through the winter.

The Silverado group, which has recently been purchased by a Vancouver syndicate headed by J. J. Coughlan, the ship-builder, is situated on a mountain across the river from the town of Stewart. A narrow vein heavily impregnated with freibergite has been traced by open-cuts between elevations of 2,000 and 4,200 ft. Some 20 tons of ore has been taken out and sacked. A sampling of this ore by the present owners just before the purchase was made gave an assay return of 1,566 oz. in silver and $2·40 in gold per ton and 14·8% of copper. A tunnel is being driven at the 2,000 ft. level, and a camp is being established at this point. The trails are being improved and brush is being cut. The syndicate will endeavour to construct a light tramway between the mine and tide-water, a distance of 8,000 ft. before the winter sets in, so that operations and shipping may be continued through the winter. Some 500 ft. of snow-shedding is being built. Should this work be completed in time it is expected that small shipments will be made regularly.

The Outland Silver Bar Co., which is developing the Outland group, 25 miles up the Salmon River, is taking out a trial shipment of 50 sacks on pack-horses. This property is 14 miles farther up the river than the Premier, and until a considerable outlay has been made to connect it with existing roads shipping on anything but a small scale is impossible. There are a number of promising prospects in the vicinity, and it is probable that the Provincial Government will construct a trail to serve all, leaving the individual owners to make trails from it to their respective properties.

Besides the foregoing, there are a number of properties in a less advanced stage, while there are many others, such as the Big Missouri and the Forty-nine, on which a considerable amount of work has been done, and in some instances on which considerable ore-bodies have been demonstrated, but on which nothing more is likely to be done until transportation or metallurgical difficulties, or both, have been solved. Taken altogether, the Salmon River district is one of great promise, and there seems to be every likelihood that several mines of importance will be developed.

PERSONAL

JOHN BALLOT is, we are pleased to hear, recovering from the serious illness from which he has been suffering recently.

B. V. BARTON has gone from Victoria to Rhodesia to become assistant general manager of the Rhodesia Broken Hill mines.

Dr. J. COGGIN BROWN is returning to India shortly, and his place at the Department of Commerce and Industry of the Indian Government at Winchester House, London, is now filled by Cyril S. Fox, also of the Indian Geological Survey.

A. G. CAMPBELL has been appointed manager of Broken Hill Block 10 mine.

F. G. COTTRELL is on his way back to the United States from Europe.

CHARLES FRÉMONT was presented with the Bessemer Medal of the Iron and Steel Institute at the recent meeting in Paris.

R. T. HANCOCK has joined the staff at the Keeley silver mines, Cobalt.

Dr. J. A. L. HENDERSON has gone to Canada.

E. G. LAWFORD has joined the staff of the Santa Gertrudis company at Pachuca, Mexico.

GEORGE MACFARLANE has returned from Australia.

H. F. MARRIOTT has left for South Africa.

E. P. MATHEWSON was here from the United States last month, and has since left for Burma.

ARTHUR MORT is returning to Baluchistan.

R. E. PALMER is paying a short visit to Canada and the United States.

C.R. PINDER is back from Mexico.

ALEX. RICHARDSON has returned to Camborne from a tour in the United States and Canada.

FRANCIS SAMUELSON is the president-elect of the Iron and Steel Institute.

WILLIAM SELKIRK, of 4, Broad Street Place, London, [illegible] has taken G. W. GRAY into

partnership. The firm will be known as W. Selkirk and Gray. Mr. Gray has been chief mining engineer at Rio Tinto for the past eight years, and latterly he was assistant general manager for the company.

CHARLES E. STEARNS has joined the metallurgical staff of the Union Minière du Haut Katanga.

J. W. TEALE and H. BLACKMAN, of Bainbridge, Seymour & Co., Ltd., have gone to South America.

A. W. WINCEY, manager of Broken Hill Block 10 mine, has gone to Papua to take charge of the Misima gold mine.

Major CLEM WEBB, founder of the *South African Mining Journal*, died last month.

Sir W. E. GARFORTH, one of the best known English coal-mining engineers, died on October 1. He was a past president of the Institution of Mining Engineers. He did much research work in connexion with colliery explosions, and was to the forefront in devising rescue apparatus.

Dr. HENRY WOODWARD died on September 6, in his 89th year. He was for many years keeper of the Geological Department at the British Museum, but probably an even greater service to science was done by him as editor of the *Geological Magazine* from its commencement in 1864 until 1918. He was an ideal editor, patient and kindly, and helpful to the authors as regards the presentation of facts and arguments in comprehensible and proper manner.

JOHN PEARCE ROE, chairman and managing director of Ropeways, Ltd., of Eldon Street House, London, E.C. 2, died on September 2. He was the son of the late John P. Roe, M.Inst.C.E., of Consett, Durham. He was born in 1852, and he commenced his career early in his father's works at Cardiff. In 1870 he went to the Dowlais Iron Company, and was engaged under the late William Menelaus and Lewis Richards, first in the drawing office, and subsequently as one of the general assistant engineers at the company's iron and steel works and collieries. In 1879, at the request of Mr. Menelaus, then chairman of the Orconera Iron Ore Company, he went to Bilbao to report progress and install provisional appliances for getting the output of the mines on board ship ; on completion of this work he was appointed resident engineer of the company, and in that capacity designed and carried out a large amount of work in connexion with the railways, shipping appliances, loading staithes, dredging, and feeder-transport arrangements to the main line, including heavy inclined-plane work. In 1889 he commenced practice as a consulting engineer at Cardiff, and undertook contracts for transporting minerals by means of aerial ropeways in the Bilbao district. In the following year he opened offices in London, and devoted himself particularly to the development of what is now known as the Roe system of ropeways for transporting material in mountainous countries. He eventually formed a company under the name of Ropeways, Limited, of which he was managing director. This company has, both as regards design and erection, carried out a great number of the most important installations in all parts of the world. In addition to supervising the entire work of the company he practised as a consulting engineer, advising on various engineering matters, and particularly in connexion with the handling and transport of minerals and the like. His biggest piece of ropeway engineering work was the Dorada ropeway, which is by far the longest in the world, that is, 47 miles. It was largely due to his inventions and improvements that the single type of ropeway has reached its present state of perfection. He had recently brought out a couple of inventions which will mark a further important advance in ropeway construction. Apart from the work with his firm, he recently invented a new type of rope conveyor, which has just been put on the market, and up to the last carried out consulting work for various projects, generally in connexion with the mechanical handling of materials. Owing to his undoubted genius in engineering and to his magnetic personality the chief members of the administrative and technical staff have been with his firm for periods of from eighteen to thirty years. This shows the high esteem in which he was held by those in close contact with him.

TRADE PARAGRAPHS

The METROPOLITAN-VICKERS ELECTRICAL CO., LTD., of Trafford Park, Manchester, and 4, Central Buildings, Westminster, send us their circular No. 1440/1, dealing with their water-wheel alternators.

W. T. GLOVER & CO., LTD., of Trafford Park, Manchester, send us their descriptive catalogue of the Glo-Clad electric wiring system. This system is useful in mines and in similar places where it is desirable that the wiring shall be water-tight, gas-light, and acid-proof.

R. B. HODGSON & CO (SHEFFIELD), LTD., of the Sentinel Steel Works, Sheffield, send us an elaborate catalogue of their special steels, containing descriptions of the steels and instructions for use. The firm's " Pinnacle " brands of drill steel are well known among mining engineers.

The BRITISH GRIFFIN CHILLED IRON AND STEEL CO., LTD., of Barrow-in-Furness, and Temple House, Tallis Street, London, E.C. 4, send us their leaflet No. 6, giving particulars of their " Boulton " self-oiling wheel, which is specially adapted to mine-cars and where there are sharp curves in the haulage.

The WESTINGHOUSE BRAKE & SAXBY SIGNAL CO., LTD., of 82, York Road, King's Cross, London, N. 1, send us their catalogue dealing with their system of electro-pneumatic control and safety appliances for mines. The appliances described embody the principles adopted in automatic signalling on railways, and they are already in extensive use in mines in connexion with hoisting plant.

EDGAR ALLEN & CO., LTD., of the Imperial Steel Works, Sheffield (London Office : 1, Victoria Street, S.W.), send us the October issue of the *Edgar Allen News*. It contains articles on modern electric furnaces, as applied in heat treatment, the application of nickel-chrome steel to the manufacture of dredge-bucket pins, and the uses and treatment of special alloy steels in Canada. There is also a description of the largest gyratory crusher made in this country, which was made for the Humber Portland Cement Co., Ltd.

The GENERAL ELECTRIC CO., LTD., of Magnet House, Kingsway, London, W.C. 2, send us their leaflet X2574, dealing with their flame-proof switchgear. They also send us their leaflet OS2569, describing the Osglim electric lamp. In this lamp no filament as used in the ordinary type of electric lamp is employed. It consists of a glass bulb similar in shape and dimensions to the ordinary

...andescent electric lamp and contains the rare gas Neon. In the bulb are fixed two metallic electrodes placed at a short distance from each other, and known as the anode and cathode, the anode being connected to the lamp contact by which the current enters, and the cathode to the contact by which it leaves. When an electric current is applied to the terminals an electric discharge or "ionic bombardment" takes place between the two metallic electrodes from the anode to the cathode. This is visible to the human eye, as light of a characteristic orange colour appearing as a luminous haze over and about the cathode. The light is particularly rich in red and yellow rays, and therefore very visible at a distance. In addition it is pleasant and soft to the eye, owing to the large area of light emission.

F. E. BECKER & Co. (Proprietors, W. and J. GEORGE, Limited), of 17–29 Hatton Wall, London, E.C. 1, are putting on the market a prospecting balance for use in connexion with alluvial tin estimations, invented by Philip Grimley, Assoc.Inst.M.M. This balance, which is on the lines of a steelyard, is designed so that if the concentrates resulting from washing ¼ cu. ft. of ground be weighed on it, the value of that sample in pounds per cubic yard can be read from the beam, which is divided into 10 units, each of which is subdivided into tenths. In addition, the weight of the concentrates can be easily ascertained. Two large and three small sliding weights are supplied. Each of the small weights has a *value* of 4·2 grams. That is, if concentrates weighing 4·2 grams are placed in the pan, the beam will be horizontal when one of the small weights is at 1, or, if the weight of the concentrates be 42·0 grams, the beam will be horizontal when the weight is at 10. One quarter of a cubic foot = 1/108 cubic yard, and 4·201 grams = 1/108 lb. So, for example, if ¼ cu. ft. of ground be washed up and when the resulting concentrates are put in the pan the beam is horizontal with one of the small weights at, say, 3·2, the value of the sample is 3·2 lb. per cu. yd., and the weight of the concentrates is 3·2 × 4·2 grams. If only one of the small weights be used, concentrates of a higher value than 10 lb. per cu. yd. have to be weighed in two or more portions, and the beam readings must be added together. But with, for example, one small weight at the mark 10 on the beam, and another of the small weights at 4, a value of 10 plus 4 = 14 lb. per cu. yd. can be read. Similarly, with the medium weight (which is twice as heavy as one of the small weights) at 10, and a small weight at 3 (as illustrated), a value of 2 × 10 plus 3 = 23 lb. per cu. yd. can be read; or with the largest weight at 10 and one of the small weights at 3, a value of 3 × 10 plus 3 = 33 lb. per cu. yd. can be read. In all the above cases the value in lb. per cu. yd. × 4·2 = weight of concentrates in grams. Further, should it, at times, be desirable to wash samples of ½ cu. ft., then the medium sized weight, at say, the mark 7, would indicate a value of 7 lb. per cu. yd. (Should any of the small weights be used when samples of ½ cu. ft. are washed its beam reading must be halved.) When ½ cu. ft. samples are taken, the weight of concentrates in grains = value in lb. per cu. yd. × 8·4. The apparatus is simple and not likely to get out of order when taken on a prospecting expedition. It weighs, in its wooden box, only 1½ lb., and the dimensions of the box are 15 in. by 4½ in. by 1¼ in. One advantage of the instrument is that it can be carried while prospecting so that the samples can be immediately tested, thus obviating error and misadventure, and giving the required information promptly.

GRIMLEY'S PROSPECTOR'S BALANCE.

SHIPPING, ENGINEERING, AND MACHINERY EXHIBITION

The Shipping, Engineering, and Machinery Exhibition was held at Olympia during the three weeks from September 7 to September 28. A few notes are given here of the exhibits of interest to mining engineers.

EDWIN ELLIS & Co., LTD., of Alpha Road, Millwall, London, E. 14, showed specimens of their "World Brand" wire ropes for shipping, engineering and mining purposes.

The EMPIRE ROLLER BEARINGS Co., LTD., of 13, Victoria Street, Westminster, had an exhibit of their "Empire" roller bearings, with a model truck on rails fitted with them.

G. A. HARVEY & Co. (LONDON), LTD., of Woolwich Road, London, S.E. 7, had a comprehensive show of their galvanized tanks, perforated metal, and woven wire-screens.

WORTHINGTON-SIMPSON, LTD., of Queen's House, Kingsway, London, W.C., showed a number of pumps, including high- and low-lift centrifugal pumps, and also air-compressors.

J. & E. HALL, LTD., of Dartford, Kent, had on exhibit characteristic plants for refrigerating and preserving food and for ice-making and cooling water.

THE METROPOLITAN-VICKERS ELECTRICAL Co., LTD., of Manchester, and Central Buildings,

Westminster, showed a great variety of their products from electric winders to lamps and bell-pushes.

HYATT, LTD., of Thurloe Place, South Kensington, had a stall displaying their flexible roller bearings.

REAVELL & CO., LTD., of Ipswich, showed a number of their air-compressors.

THE UNCHOKEABLE PUMP, LTD., of 3, St. Helen's Place, London, E.C. 3, showed their centrifugal pump in action. This pump is used for handling soft materials in water, and also hard materials, such as gravel and tailings.

THE ATLAS DIESEL CO., LTD., of 35, Surrey Street, London, W.C. 2, exhibited a number of their specialities: a crude-oil engine, air-compressor, rock-drills, and coal pick-hammers.

FERODO, LTD., of Chapel-en-le-Frith, showed their stair-treads and their friction linings for breaks and clutches.

COWLISHAW, WALKER & CO., LTD., of Stoke-on-Trent, had a representative exhibit of the coal-cutting machinery, and their haulage plant for mines.

GEOGE KENT, LTD., of 199-201, High Holborn, London, W.C. 1, showed a great number of measuring instruments, including the Venturi meter for measuring the flow of water or gas.

JOHN KIRKALDY, LTD., of 101, Leadenhall Street, London, E.C. 3, showed many applications of their cooling and distilling plants, which are nowadays used extensively at mines for a variety of purposes.

W. H. DORMAN & CO., LTD., of Stafford, made a special show of "Flexstel" piping, the universal joints of which will withstand very high pressures. At the same stand VISLOK, LTD., demonstrated their well-known lock-nut.

THE DE LAVAL STEAM TURBINE CO., of 150, Southampton Row, London, W.C. 2, showed centrifugal pumps, steam turbine, centrifugal blower, etc.

JOHN & EDWIN WRIGHT, LTD., of the Universe Rope Works, Birmingham, and Salisbury House, London, E.C. 2, had a comprehensive exhibit of hemp and wire ropes. These ropes have a large application in mining.

THE PALNUT CO., LTD., of 6, Great St. Helens, London, E.C. 3, showed their safety lock-washer, which was described and illustrated in the MAGAZINE for June last.

SOZOL, LTD., of 20, Copthall Avenue, London, E.C. 2 (which is associated with Minerals Separation, Ltd.), exhibited their anti-rust and anti-corrosion preparations.

The CONSOLIDATED PNEUMATIC TOOL CO., LTD., of 170, Piccadilly, London, W. 1, showed the Hummer rock-drills, the Boyer riveting hammers, and the Little Giant pneumatic and electric drills and grinders.

METAL MARKETS

COPPER.—The standard copper market in London presented quite a steady appearance during September, and fluctuations were within narrow limits. At the beginning of the month prices tended to harden as the result of support believed to emanate chiefly from America, but the upward spurt was not maintained, and subsequent advances were also short-lived. The fact was pretty plainly evident that sentiment was, if anything, pessimistic rather than optimistic, and that conditions were not ripe for any substantial rise in values. The close of the month, however, witnessed a slight revival, and the American quotation also began to harden. The demand from English consumers continued rather unsatisfactory during the month, and although at times the Continent bought moderately, the depreciation in European exchanges tended to restrict the volume of demand from that quarter. Germany, in particular, has been hard hit by the rapid fall in the mark, and reports from the United States would indicate that her purchases there are smaller than recently. In face of the diminished European demand it is rather surprising that the American quotation should have kept firm, especially as consumers there are also taking metal on a small scale only; this, however, is accounted for by the stiff attitude of producers, who seem always eager to push up the quotation at the first sign of improved demand. In the meantime, on both sides of the Atlantic the existence of large quantities of scrap copper and brass continues to have a restraining influence on the demand for virgin metal. Some large deals, however, have recently taken place in British war-scrap, and it looks as if the point of absorption has been brought appreciably nearer. The quarterly reports of the Chino Copper Company, Nevada Consolidated, Ray Consolidated, Utah Copper, and Anaconda Copper Co., all of which are shut down, indicate that they are finding the suspension of operations quite an expensive procedure, and it is to be imagined that most of the mines will reopen immediately the situation looks favourable. In the meantime, however, the large stocks of unabsorbed copper in the United States act as a deterrent.

Average price of cash standard copper: September, 1921, £68 0s. 11d.; August, 1921, £68 12s. 8d.; September, 1920, £96 13s. 4d.; August, 1920, £94 1s.

TIN.—The chief feature of the standard tin market in London during the past month was the upward rise of values during the first few days as a result of the publication of the statistics for August, which indicated a decrease in the visible supplies. This had the effect of infusing an appreciable amount of optimism into the market, and prices rose in consequence. The main factor contributing to this decrease was an expansion in American deliveries, but it was overlooked in some quarters that since American consumption had shown no appreciable improvement, the bulk of the extra metal taken must necessarily have been put into stock; this view, of course, gave the situation a less favourable aspect. In any case, however, the rise in values was not maintained, and by the middle of the month values were back on the level ruling at the opening. It may be mentioned that the United States did not follow the advance here to any extent. Towards the end of the month sentiment again took a more optimistic turn, and, thanks to reports of an improvement in the tinplate industries of South Wales and Pittsburgh, values rose again, but more steadily and slowly. As regards the Continent, Italy, France, and Germany were occasional buyers, but naturally the adverse position of their respective exchanges tended to restrict their takings. During the month the East made fair sales, though sellers there were inclined to hold aloof whenever the market in London was firm. Shipments from the Straits were, however, fairly big during the month. China for various reasons did not feature as a seller.

DAILY LONDON METAL PRICES: OFFICIAL CLOSING
Copper, Lead, Zinc, and Tin per Long Ton

COPPER

	Standard Cash	Standard (3 mos.)	Electrolytic	Wire Bars	Best Selected
Sept.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.
12	67 5 0 to 67 7 6	68 5 0 to 68 10 0	71 10 0 to 73 10 0	72 10 0 to 73 0 0	68 5 0 to 70 5 0
13	67 17 6 to 68 0 0	68 17 6 to 69 0 0	72 0 0 to 73 10 0	72 10 0 to 73 0 0	69 10 0 to 71 10 0
14	67 17 6 to 68 0 0	68 17 6 to 69 0 0	72 10 0 to 74 0 0	73 0 0 to 73 10 0	69 10 0 to 71 10 0
15	67 12 6 to 67 15 0	68 10 0 to 68 12 6	72 10 0 to 74 0 0	73 0 0 to 73 10 0	69 10 0 to 71 10 0
16	67 15 0 to 67 17 6	68 12 6 to 68 15 0	72 10 0 to 74 0 0	73 5 0 to 73 15 0	69 0 0 to 71 0 0
19	68 2 6 to 68 5 0	68 17 6 to 69 0 0	72 10 0 to 74 10 0	73 10 0 to 74 10 0	69 0 0 to 71 0 0
20	67 15 0 to 68 0 0	68 10 0 to 68 12 6	72 0 0 to 74 0 0	73 0 0 to 74 0 0	68 10 0 to 70 10 0
21	67 12 6 to 67 17 6	68 10 0 to 68 12 6	72 0 0 to 74 0 0	73 0 0 to 74 0 0	68 10 0 to 70 10 0
22	67 12 6 to 67 17 6	68 10 0 to 68 15 0	72 0 0 to 74 0 0	73 0 0 to 74 0 0	68 10 0 to 70 10 0
23	67 15 0 to 67 17 6	68 10 0 to 68 12 6	72 0 0 to 74 0 0	73 0 0 to 74 0 0	68 10 0 to 70 10 0
26	68 0 0 to 68 2 6	68 15 0 to 68 17 6	72 10 0 to 74 10 0	73 10 0 to 74 10 0	68 10 0 to 70 10 0
27	68 0 0 to 68 2 6	68 15 0 to 69 0 0	72 10 0 to 74 10 0	73 10 0 to 74 10 0	69 0 0 to 71 0 0
28	68 7 6 to 68 10 0	69 5 0 to 69 7 6	72 10 0 to 74 10 0	73 10 0 to 74 10 0	69 0 0 to 71 0 0
29	68 5 0 to 68 7 6	69 5 0 to 69 7 6	72 10 0 to 74 10 0	73 10 0 to 74 10 0	69 0 0 to 71 0 0
30	68 7 6 to 68 10 0	69 7 6 to 69 10 0	72 10 0 to 74 10 0	73 10 0 to 74 10 0	69 10 0 to 71 10 0
Oct.					
3	68 7 6 to 68 12 6	69 7 6 to 69 10 0	72 10 0 to 74 10 0	73 10 0 to 74 10 0	69 10 0 to 71 10 0
4	68 12 6 to 68 15 0	69 10 0 to 69 12 6	73 0 0 to 74 10 0	74 0 0 to 74 10 0	69 10 0 to 71 10 0
5	69 7 6 to 69 10 0	70 5 0 to 70 7 6	73 10 0 to 75 10 0	73 10 0 to 75 10 0	69 10 0 to 71 10 0
6	69 0 0 to 69 2 6	70 0 0 to 70 2 6	74 0 0 to 76 0 0	75 0 0 to 76 0 0	69 10 0 to 71 10 0
7	69 7 6 to 69 10 0	70 7 6 to 70 10 0	74 10 0 to 76 10 0	75 10 0 to 76 10 0	70 0 0 to 71 10 0
10	69 5 0 to 69 7 6	70 5 0 to 70 7 6	75 10 0 to 77 10 0	75 10 0 to 77 10 0	70 0 0 to 71 10 0

Average price of cash standard tin: September, 1921, £156 17s. 6d.; August, 1921, £155 8s. 4d.; September, 1920, £270 7s. 3d.; August, 1920, £274 5s. 10d.

LEAD.—Price movements on the London lead market during September were within a comparatively small compass, the general tendency being slightly downwards. A moderate recovery towards the end of the month seemed to be due to covering by bears. On the whole, supplies of lead were less tightly held than previously, and holders of spot in particular relaxed their firm attitude. In consequence, the backwardation, or discount on forward delivery, gradually diminished. It must be admitted that as a result of this the position of the market looks somewhat less artificial than formerly, although, relatively, lead is dearer than either copper, tin, or spelter; and as demand from consumers has latterly shown a declining tendency, it would not be surprising if values were to suffer further. Arrivals of metal from Spain were on a comparatively small scale during the month, probably owing to labour troubles and the diminution of stocks, but this shortage was compensated by shipments from America and even Australia. There was at times quite a good demand from the Continent, but British dealers encountered considerable competition in European markets by American interests. Towards the end of the month, however, the price in New York hardened appreciably to 4·70 cents, and offerings to this country tended to decrease. Germany has been displaying activity as a lead consumer, and in addition to her domestic output finds it necessary to import. It is understood that a syndicate has been formed with a view to reopening some of the Derbyshire lead mines, which were worked during the war, but have since been abandoned.

Average price of soft pig lead: September, 1921, £22 19s. 5d.; August, 1921, £23 5s. 1d.; September, 1920, £35 7s. 6d.; August, 1920, £36 8s. 10d.

SPELTER.—Values on the London spelter market showed a net gain on the month. The opposite might have been anticipated with some reason, as the marked weakness which set in during September in both the Belgian and German exchanges was a possible cause of offerings from those countries. A little metal was certainly forthcoming occasionally from Belgium, but Germany held practically aloof, despite the temptation to realize in London which the mark at 400 must have presented. It would appear that stocks in Germany must be now of quite moderate dimensions, and that domestic consumption can look after a good part of present output, especially as the Silesian smelters cannot be working at full pressure. Further firmness was instilled into the market by the announcement that the stocks in the United States had been reduced during August by some 6,000 tons, which was regarded favourably in view of the fact that stocks there had been piling up for some time past. It is interesting to note that the Belgian output during August was slightly in excess of the July figure, namely, 5,000 tons compared with 4,950 tons. As regards the works in the north of France it is stated that these are working at half pre-war capacity, and do not appear likely to increase their output for some considerable time. A welcome development during the month was an improvement in the galvanizing industry, which brought out more consuming demand for spelter and helped to give the market a healthier tone. In the United States, also, consumers are reported to be taking rather more interest, and the price advanced there also. It looks as if Australasia will be a big producer of spelter in the near future. The Risdon electrolytic zinc works, which were commenced during the war, and have a potential output of 42,500 tons of electrolytic zinc, have purchased some 750,000 tons of concentrates and slimes from the British Board of Trade for treatment. Some Swansea works are contemplating resuming operations.

Average price of spelter: September, 1921, £26 10s. 8d.; August, 1921, £25 8s.; September, 1920, £40 5s. 6d.; August, 1920, £41 19s. 6d.

ZINC DUST.—Prices are lower; high-grade Australian £50; English and American 92 to 94% about £48 per ton.

PRICES ON THE LONDON METAL EXCHANGE.
Silver per Standard Ounce ; Gold per Fine Ounce.

Lead: Soft Foreign	Lead: English	Zinc (Spelter)	Standard Tin: Cash	Standard Tin: 3 mos.	Silver: Cash	Silver: Forward	Gold	
£ s. d. £ s. d.	£ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	d.	d.	s. d.	Sept.
23 12 6 to 23 0 0	24 10 0	24 15 0 to 25 10 0	156 0 0 to 156 5 0	158 5 0 to 158 10 0	39	38⅝	110 2	12
23 5 0 to 22 15 0	24 5 0	25 0 0 to 25 10 0	156 12 6 to 156 17 6	158 15 0 to 159 0 0	39⅝	39¼	110 3	13
23 5 0 to 22 15 0	24 5 0	25 2 6 to 25 12 6	155 15 0 to 156 0 0	158 0 0 to 158 5 0	39⅝	39¼	110 4	14
23 5 0 to 22 15 0	24 5 0	25 0 0 to 25 10 0	155 0 0 to 155 5 0	157 5 0 to 157 10 0	39⅜	39	111 6	15
23 2 6 to 22 15 0	24 5 0	24 17 6 to 25 7 6	154 5 0 to 154 10 0	156 10 0 to 156 15 0	39⅛	39¼	110 10	16
22 17 6 to 22 12 6	24 0 0	25 0 0 to 25 10 0	154 7 6 to 154 12 6	156 12 6 to 156 15 0	39¼	39⅛	110 3	19
22 15 0 to 22 12 6	24 0 0	25 0 0 to 25 10 0	155 10 0 to 155 15 0	157 15 0 to 158 0 0	39⅞	39⅝	110 6	20
23 0 0 to 22 15 0	24 0 0	25 5 0 to 25 12 6	156 0 0 to 156 5 0	158 0 0 to 158 5 0	40	39¾	110 7	21
22 15 0 to 22 12 6	23 15 0	25 5 0 to 25 12 6	156 2 6 to 156 7 6	158 2 6 to 158 7 6	41⅛	41¼	110 11	22
22 15 0 to 22 10 0	23 15 0	25 7 6 to 25 15 0	156 5 0 to 156 7 6	158 5 0 to 158 7 6	41⅛	41¼	110 9	23
23 5 0 to 23 0 0	24 5 0	25 12 6 to 26 2 6	157 10 0 to 157 15 0	159 15 0 to 160 0 0	41⅞	41¼	110 11	26
23 2 6 to 22 17 6	24 5 0	26 0 0 to 26 10 0	157 2 6 to 157 7 6	159 5 0 to 159 10 0	43⅜	43⅛	110 11	27
23 0 0 to 23 0 0	24 5 0	26 7 6 to 26 15 0	156 10 0 to 156 15 0	158 10 0 to 158 15 0	43⅛	42⅞	110 11	28
23 2 6 to 23 0 0	24 5 0	26 7 6 to 26 15 0	156 5 0 to 156 10 0	158 10 0 to 158 15 0	43¼	43	111 4	29
23 2 6 to 22 17 6	24 5 0	26 7 6 to 26 15 0	156 10 0 to 156 15 0	158 7 6 to 158 10 0	42⅝	42½	111 0	30
								Oct.
23 5 0 to 23 2 6	24 5 0	26 7 6 to 26 17 6	157 5 0 to 157 10 0	159 10 0 to 159 15 0	42⅛	41⅞	—	3
23 5 0 to 23 2 6	24 5 0	26 10 0 to 27 0 0	156 10 0 to 156 15 0	158 10 0 to 158 15 0	42½	42⅜	110 6	4
23 5 0 to 23 2 6	24 5 0	26 15 0 to 27 5 0	155 15 0 to 156 0 0	157 15 0 to 158 0 0	42⅛	41⅞	109 8	5
23 5 0 to 23 2 6	24 5 0	26 12 6 to 27 2 6	155 10 0 to 155 15 0	157 15 0 to 158 0 0	41¼	41	108 7	6
23 2 6 to 22 17 6	24 5 0	26 12 6 to 27 2 6	155 0 0 to 155 5 0	157 10 0 to 157 15 0	41¾	41⅝	108 8	7
23 2 6 to 22 17 6	24 5 0	26 12 6 to 27 2 6	155 15 0 to 156 0 0	157 15 0 to 158 0 0	42¼	42	107 5	10

ANTIMONY.—Values have kept very steady as follow : English regulus ordinary brands, £37 to £40 ; special brands, £38 5s. to £42 ; and 98 to 99% £29 to £32. Foreign in warehouse is about £24 10s. to £25 10s. per ton.

ARSENIC.—Towards the end of the month consumers entered the market fairly freely, in anticipation of the effects of the Key Industries Act, and the price of Cornish white rose from £32 7s. to £43 per ton, delivered London.

BISMUTH.—The quotation is unchanged at 7s. 6d. per lb.

CADMIUM.—Business is quiet at about 6s. per lb.

ALUMINIUM.—Values have remained practically unaltered. Domestic producers quote £120 for home and £125 for export, while foreign metal is apparently still obtainable around £100 f.o.b. Continent.

NICKEL.—The tendency has been a little easier, the quotation being £185 to £190 per ton.

COBALT METAL.—The price has weakened slightly to 14s. per lb.

COBALT OXIDE.—Quotations are lower on the month, black being priced at 10s. 9d. and grey at 12s. per lb.

PLATINUM AND PALLADIUM.—Platinum has been rather firmer, manufactured metal being quoted at £20 10s., and raw at £19. Palladium is steady, with manufactured material priced at £18 to £20 per oz., and raw at £14 to £15.

QUICKSILVER.—Values are lower on the month, the leading interests having reduced their quotation to £9 10s. per bottle. At the moment the market is steady.

SELENIUM.—The price is steady at 10s. 6d. to 13s. per lb.

TELLURIUM.—Sellers still quote 80s. to 90s. per lb.

SULPHATE OF COPPER.—The price is unchanged on the month at £30 to £32 per ton for both home and export.

MANGANESE ORE.—There has recently been a firmer tendency in the market for Indian grades, owing to the rise in the rupee, and the present quotation is 1s. 4½d. per unit c.i.f.

TUNGSTEN ORE.—The market is very quiet, with the quotation for 65% WO_3 none too well maintained at 12s. 6d. to 13s. c.i.f.

MOLYBDENITE.—Sellers of 85% molybdenite continue to quote 37s. 6d. to 42s. 6d. c.i.f.

CHROME ORES. — The present price is about £4 7s. 6d. c.i.f.

SILVER.—The market was quiet at the beginning of the month, but later Chinese and Indian buying caused prices to advance. The quotation for spot bars opened on September 1 at 37¾d., rose to 39⅛d. on the 6th, reacted to 38¾d. on the 8th, advanced again to 39⅝d. on the 13th, and after weakening to 39⅜d. on the 15th, took a definitely upward turn till 43⅜d. was reached on the 27th. The price closed at 42⅝d. on the 30th.

GRAPHITE.—Quotations are rather nominal, and there is no change to report, Madagascar 80 to 90% being still £20 to £25 per ton c.i.f.

IRON AND STEEL.—It cannot be said that much progress is being made in getting the pig iron trade into full swing again. Of course, the old stumbling-block is the high price of fuel, which in turn prevents ironmasters from bringing prices of pig iron down to more reasonable levels. True, the price of Cleveland foundry is now down to 120s., which was the official minimum price fixed some time ago, but even this figure consumers show little disposition to pay, especially seeing that they can obtain supplies from the Continent at much lower levels. The total number of furnaces blowing in the Cleveland district at the present time is only seventeen out of seventy-two. A welcome feature of the semi-finished steel business is the elimination of Continental competition, British makers now being able to book orders at prices below those asked by the makers across the water. In finished steel, however, British producers have a long way to go before they can compete, but the tendency is downwards, and further drops are anticipated before long. Of course, if fuel—and consequently pig iron—came down, we should no doubt see substantial reductions in steel prices. As regards export, makers have been cutting prices to get business, but, with the exception of the far East, few markets are showing much interest.

STATISTICS

Production of Gold in the Transvaal.

	Rand	Elsewhere	Total	Price of
	Oz.	Oz.	Oz.	Gold per oz.
				s. d.
August 1920	683,634	18,479	702,083	112 6
September	665,486	16,687	682,173	115 0
October	645,819	16,653	662,472	117 6
November	618,525	15,212	633,737	117 6
December	617,549	14,666	632,215	115 0
Total, 1920	7,949,038	204,587	8,153,625	—
January, 1921	637,425	14,168	651,593	105 0
February	543,767	14,370	558,137	103 9
March	656,572	14,551	671,123	103 9
April	665,309	16,073	681,382	103 9
May	671,750	16,026	687,776	103 9
June	663,383	15,107	678,490	107 6
July	673,475	16,080	689,555	112 6
August	696,230	15,296	711,526	111 6

Natives Employed in the Transvaal Mines.

	Gold mines	Coal mines	Diamond mines	Total
August 31, 1920	169,263	13,535	4,244	187,042
September 30	163,132	13,716	4,323	181,171
October 31	159,426	13,858	4,214	177,498
November 30	158,773	14,245	3,504	176,522
December 31	159,671	14,263	3,340	177,274
January 31, 1921	165,287	14,541	3,319	183,147
February 28	171,518	14,697	1,612	187,827
March 31	174,364	14,936	1,364	190,664
April 30	172,826	14,908	1,316	189,050
May 31	170,595	14,510	1,302	186,407
June 30	168,152	14,704	1,317	184,173
July 31	166,999	14,688	1,246	182,933
August 31	168,008	14,446	1,207	184,661

Cost and Profit on the Rand.

Compiled from official statistics published by the Transvaal Chamber of Mines.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
August, 1920	2,057,560	36 11	25 0	11 11	1,226,906
September	1,950,410	38 11	25 6	13 5	1,276,369
October	1,871,140	39 9	26 1	13 8	1,278,385
November	1,799,710	40 2	26 3	13 1	1,255,749
December	1,797,970	39 11	26 8	13 3	1,193,672
January, 1921	1,895,235	35 0	26 3	8 9	829,436
February	1,575,320	35 6	28 6	7 0	550,974
March	1,958,730	34 5	26 1	8 4	813,636
April	1,991,815	34 5	25 10	8 7	854,533
May	1,955,357	35 3	26 2	9 1	889,520
June	1,966,349	35 10	25 10	10 0	979,769
July	2,010,256	37 2	25 7	11 7	1,163,565

Production of Gold in Rhodesia.

	1919	1920	1921
	£	oz.	oz.
January	211,917	43,428	46,956
February	220,885	44,237	40,816
March	225,808	45,779	31,995
April	213,160	47,000	47,858
May	218,057	46,266	48,744
June	214,215	45,054	49,466
July	214,919	46,208	51,564
August	207,339	48,740	[illegible]
September	223,719	45,471	—
October	204,184	47,342	—
November	186,462	46,782	—
December	158,835	46,190	—
Total	2,499,498	552,498	[illegible]

Transvaal Gold Outputs.

	July		August	
	Treated Tons	Yield Oz.	Treated Tons	Yield Oz.
Aurora West	10,680	£15,823†	11,050	£16,100*
Brakpan	58,000	21,909	58,000	22,178
City Deep	84,000	35,578	90,000	37,064
Cons. Langlaagte	42,300	£71,673†	44,000	£72,592*
Cons. Main Reef	50,700	17,060	48,000	15,758
Crown Mines	201,000	59,092	196,000	57,829
D'rb'n Roodepoort Deep	27,400	9,448	27,600	9,048
East Rand P.M.	127,000	34,252	126,000	33,300
Ferreira Deep	32,300	10,022	34,500	11,328
Geduld	45,300	15,655	44,500	15,621
Geldenhuis Deep	51,387	13,324	50,697	13,593
Glynn's Lydenburg	3,630	£7,153§	3,446	£7,124‡
Goch	17,000	£20,441†	17,500	£21,390*
Government G.M. Areas	140,000	£297,622†	145,000	£327,065*
Kleinfontein	50,100	13,743	51,900	13,679
Knight Central	28,600	6,761	29,200	7,228
Langlaagte Estate	40,300	£69,991†	41,300	£70,020*
Luipaard's Vlei	22,560	£31,484†	22,515	£28,265*
Meyer & Charlton	13,500	£42,715†	11,500	£45,044*
Modderfontein	96,000	46,454	100,000	48,111
Modderfontein B	59,000	33,047	60,000	31,152
Modderfontein Deep	42,500	23,978	44,400	21,818
Modderfontein East	26,350	10,172	27,300	12,316
New Unified	11,500	£13,536†	11,500	£13,892*
Nourse	43,400	13,501	45,000	14,68[illegible]
Primrose	22,000	£26,315†	22,800	£27,327*
Randfontein Central	127,000	£211,792†	135,580	£218,405*
Robinson	38,000	7,571	40,000	7,620
Robinson Deep	60,200	17,759	61,630	17,871
Roodepoort United	22,600	£25,514†	23,000	£24,031*
Rose Deep	54,400	13,292	56,200	13,141
Simmer & Jack	57,500	13,251	58,760	13,772
Springs	40,000	18,572	41,500	18,179
Sub Nigel	10,000	5,461	10,200	5,491
Transvaal G.M. Estates	16,010	£25,878§	15,600	£27,271‡
Van Ryn	33,400	£50,730†	33,400	£53,016*
Van Ryn Deep	49,300	£148,588†	55,300	£165,128*
Village Deep	50,000	16,152	50,000	16,196
West Rand Consolidated	32,000	£49,712†	32,500	£49,900*
Witw'tersr'nd (Knights)	37,700	£52,862†	41,300	£58,779*
Witwatersrand Deep	31,759	9,178	31,000	9,423
Wolhuter	33,500	8,278	32,300	8,217

* Gold at £5 11s. 6d. per oz. † £5 12s. 6d. per oz. ‡ £5 9s. 9d. per oz. § £5 11s. per oz.

Rhodesian Gold Outputs.

	July		August	
	Tons	Oz.	Tons	Oz.
Cam & Motor	12,800	4,060	13,000	4,355
Falcon	15,718	3,425*	16,024	3,346‖
Gaika	3,704	1,242	3,788	1,323
Globe & Phœnix	6,079	5,892	6,268	5,817
Jumbo	1,500	483	1,580	476
London & Rhodesian	2,409	£3,170	2,473	£3,054
Lonely Reef	5,400	5,180	5,170	4,901
Planet-Arcturus	5,840	2,689	5,600	2,495
Rezende	5,850	2,582	5,800	2,650
Rhodesia G.M. & I.	338	346	307	355
Shamva	54,150	£41,500§	53,750	£[illegible]§
Transvaal & Rhodesian	1,550	£4,400†	1,450	£4,641†

* Also 243 tons copper. † At par. ‖ Also 270 tons copper. § Gold at £5 10s. per oz.

West African Gold Outputs.

	July		August	
	Treated	Value	Treated	Value
	Tons	Oz.	Tons	Oz.
Abbontiakoon	7,200	£12,476*	8,000	£13,853*
Abosso	5,767	2,278	6,239	2,496
Akoko	—	—	—	—
Ashanti Goldfields	7,077	6,085	7,356	7,760
Eastern Akim	—	85	—	—
Obbuassi	901	£2,574†	800	£3,440†
Prestea Block A	8,093	£13,006*	8,094	£15,567*
Taquah	[illegible]	1,823	3,340	2,065

* At par. † Including premium.

West Australian Gold Statistics.—Par Values.

	Reported for Export Oz.	Delivered to Mint Oz.	Total Oz.	Total Value £
December, 1920 ...	321	53,595	53,916	229,057
January, 1921	523	50,934	51,457	218,574
February	684	26,872	27,556	117,050
March............	10	47,875	47,885	203,401
April	607	46,602	47,209	200,635
May	474	47,638	51,503	217,495
June............	153	28,194	28,347	120,410
July	1,641	44,917	46,558	197,774
August...........	110	51,731	51,841	220,205
September........	380	50,728	51,108	217,092

Australian Gold Outputs.

	West Australia	Victoria	Queensland	New South Wales
1921	oz.	oz.	oz.	£
January .	51,458	4,587	4,582	20,463
February.	27,557	10,940	9,046	21,575
March ...	47,886	12,383	6,690	24,344
April	47,273	5,954	2,591	34,101
May	48,113	10,280	2,077	15,356
June.....	28,347	10,431	1,602	11,640
July	—	—	—	16,416
August...	—	—	—	15,946
September	—	—	—	—
October .	—	—	—	—
November	—	—	—	—
December	—	—	—	—
Total ..	250,634	54,577	26,588	160,041

Australasian Gold Outputs.

	July		August	
	Tons	Value £	Tons	Value £
Associated G.M. (W.A.)	5,962	8,329‖	6,217	8,313‖
Blackwater (N.Z.)	2,809	5,176*	2,805	5,405*
Bullfinch (W.A.)	—	—	—	—
Gold'n Horseshoe (W.A)	10,224	5,332‡	10,512	5,483‡
Grt Boulder Pro. (W.A.)	9,188	28,712‖	9,438	29,494‖
Ivanhoe (W.A.)	15,106	5,634‡	16,126	6,185‡
Kalgurli (W.A.)	2,370	4,298‖	—	—
Lake View & Star (W.A.)	6,582	14,625†‖	6,765	15,701†‖
Menzies Con. (W.A.) ..	1,070	5,511	—	—
Mount Boppy (N.S.W.)	2,404	932‡	4,405	1,111‡
Oroya Links (W.A.) ...	1,330	7,113†‖	1,633	8,146†‖
Progress (N.Z.)........	—	—	—	—
Sons of Gwalia (W.A.) .	—	—	—	—
South Kalgurli (W.A.) .	7,857	12,488‖	7,862	12,700‖
Waihi (N.Z.)...........	12,950	4,033‡ 42,384§	14,197	4,480‡ 14,829§
,, Grand Junc'n (N.Z.)	5,570	1,558‡ 4,541§	6,380	1,499‡ 3,344§
Yuanmi (W.A.)	—	—	—	—

* Including premium; † Including royalties; ‡ Oz. gold; § Oz. silver; ‖ At par.

Miscellaneous Gold and Silver Outputs.

	July		August	
	Tons	Value £	Tons	Value £
Brit. Plat. & Gold (C'lbia)	—	512§‡‡	—	254§
Cascalho (Brazil)........	—	32††	—	19c
Chuquitambo (Peru).....	1,400	1,000*	1,800	1,250*
El Oro (Mexico)	34,750	198,000†	34,700	196,000†
Esperanza (Mexico)	—	698†‡	—	300†‡
Frontino & Bolivia (C'lbia)	2,150	10,106*	2,160	8,608*
Keeley Silver (Canada) ..	5,554	32,987	—	—
Mexico El Oro (Mexico)..	—	—	—	—
Mining Corp. of Canada .	8,435	125,915	—	—
Oriental Cons. (Korea) ...	19,297	86,234†	—	75,500†
Ouro Preto (Brazil)	7,500	2,503‖	7,100	2,370‖
Plym'th Cons. (Calif'rnia	7,200	8,704*	8,200	6,913*
St. John del Rey (Brazil).	—	40,000*	—	43,000*
Santa Gertrudis (Mexico)	38,250	13,938‡	29,762	16,227‡
Tolima (Colombia)	—	—	—	—
Tomboy (Colorado)	16,000	64,000†	18,000	69,000†

* At par. † U.S. Dollars. ‡ Profit, gold and silver. ‖ Oz. gold. § Oz. platinum and gold. ** Production of silver ore. †† Oz. gold, also 155 carats of diamonds. ‡‡ Eight weeks to August 13. §§ Oz. silver. c Oz. gold, also 131 carats of diamonds.

Nechi (Colombia): 10 days to September 1, $21,014 from 79,485 cu. yd.; 8 days to September 9, $31,050 from 58,311 cu. yd.

Pato (Colombia): 20 days to September 13, $27,334 from 109,088 cu. yd.

Indian Gold Outputs.

	July		August	
	Tons Treated	Fine Ounces	Tons Treated	Fine Ounces
Balaghat	3,300	2,364	3,300	2,361
Champion Reef	12,250	4,713	12,127	4,822
Mysore...............	17,090	10,517	17,313	10,498
North Anantapur	700	908	700	904
Nundydroog	9,048	5,337	9,160	5,370
Ooregum	12,000	8,439	12,900	8 543

Production of Gold in India.

	1917	1918	1919	1920	1921
	Oz.	Oz.	Oz.	Oz.	Oz.
January	44,718	41,420	38,184	39,073	34,028
February ...	42,566	40,787	36,384	38,872	32,529
March	44,617	41,719	38,317	38,760	32,576
April	43,726	41,504	38,248	37,307	32,363
May........	42,901	40,889	38,608	38,191	32,656
June	42,924	41,264	38,359	37,864	32,207
July	42,273	40,229	38,549	37,129	32,278
August	42,591	40,496	37,850	37,375	32,498
September ..	43,207	40,088	36,813	35,497	—
October	43,041	39,472	37,138	35,023	—
November ..	42,915	36,984	39,628	34,522	—
December ..	44,883	40,149	42,643	34,919	—
Total ..	520,362	485,236	461,171	444,532	261,145

Base Metal Outputs.

		July	August
Arizona Copper	Short tons copper ...	—	—
British Broken Hill ...	Tons lead conc. ...	—	—
	Tons zinc conc.	—	—
	Tons carbonate ore	—	—
Broken Hill Prop......	Tons lead conc. ...	—	—
	Tons zinc conc.	—	—
Broken Hill South	Tons lead conc.	4,709	2,935
Burma Corporation....	Tons refined lead ..	3,239	2,598
	Oz. refined silver ..	302,499	260,900
Hampden Cloncurry ..	Tons copper	—	—
	Oz. gold	—	—
Mount Lyell	Tons copper	446	470
	Oz. silver	14,479	14,056
	Oz. gold	385	342
Mount Morgan	Tons Copper	—	—
	Oz. gold	—	—
Pilbara	Tons copper ore	111	90
North Broken Hill.....	Tons lead conc......	1,200	1,200
	Tons zinc conc......	1,170	1,170
Rhodesia Broken Hill	Tons lead	1,575	1,569
Sulphide Corporation ..	Tons lead conc. ...	2,183	2,089
	Tons zinc conc	3,671	3,739
Tanganyika	Tons copper	3,189	2,952
Zinc Corporation	Tons zinc conc......	9,195	9,805
	Tons lead conc. ...	925	967

Imports of Ores, Metals, etc., into United Kingdom.

		July	August
Coal	Tons	1,389,981	167,133
Iron Ore	Tons	14,857	36,997
Manganese Ore	Tons	4,789	6,039
Copper and Iron Pyrites	Tons	2,933	16,375
Copper Ore, Matte, and Prec.	Tons	689	1,074
Copper Metal	Tons	2,554	8,317
Tin Concentrate	Tons	1,002	1,231
Tin Metal.....................	Tons	2,188	2,086
Lead, Pig and Sheet	Tons	12,718	10,845
Zinc (Spelter)	Tons	2,743	3,907
Quicksilver	Lb.	343,176	112
Zinc Oxide....................	Tons	350	509
White Lead	Cwt.	7,884	2,705
Barytes, ground	Cwt.	20,490	28,714
Phosphate	Tons	8,561	15,697
Sulphur	Tons	—	—
Nitrate of Soda.................	Cwt.	23,130	19,197
Petroleum			
Crude	Gallons	13,271,705	9,501,804
Lamp Oil	Gallons	12,940,684	9,784,263
Motor Spirit	Gallons	13,952,940	21,146,947
Lubricating Oil	Gallons	3,545,107	2,176,031
Gas Oil	Gallons	12,666,828	11,901,765
Fuel Oil	Gallons	64,079,318	52,422,202

[illegible] Tin Mining Companies.

In Tons of Concentrate.

	June	July	August
Nigeria:	Tons	Tons	Tons
Associated Nigerian	—	—	—
Bisichi	33	35	[illegible]
[illegible]	—	—	—
Champion Nigerian	-	—	—
[illegible]	—	—	—
Ex-Lands	-	2	—
[illegible]	[illegible]	—	[illegible]
Gold Coast Consolidated	1¼	2½	[illegible]
Gurum River	10	13	13
Jantar	-	—	—
Jos	7	5½	[illegible]
Kaduna	10½	11½	[illegible]
Kaduna Prospectors	1	7¼	[illegible]
Kano	—	—	—
Keffi Consolidated	15	23	—
Lower Bisichi	-	3½	4½
Lucky Chance	—	—	—
Mario	—	—	—
Mongu	35	37	[illegible]
Naraguta	38	59	50
Naraguta Extended	20	20	24
Nigerian Consolidated	9	8	[illegible]
N.N. Bauchi	64	65	[illegible]
Offin River	—	—	—
Rayfield	31	37	26
Ropp	104	118	[illegible]
Rukuba	3	4	5
South Bukeru	16	16	—
Sybu	1¼	—	—
Tin Fields	6	8	11
Yarde Kerri	9½	6	7
Federated Malay States:			
Chenderiang	69*	—	—
Gopeng	86½	89	[illegible]
Idris Hydraulic	13½	17¾	[illegible]
Ipoh	5¼	22	[illegible]
Kamunting	82*	—	—
Kinta	35¼	35¾	35¾
Labat	52	53½	43½
Malayan Tin	86¼	86¼	[illegible]
Pahang	240	214	216
Rambutan	15	14	15
Sungei Besi	33	47	48
Tekka	26	37	37
Tekka-Taiping	21½	20	36
Trench	26	32	[illegible]
Cornwall:			
East Pool	—	—	—
Geevor	—	—	—
South Crofty	—	—	—
Other Countries:			
Aramayo Mines (Bolivia)	165	180	174
Berenguela (Bolivia)	28	28	28
Briseis (Tasmania)	9	—	10
Deebook Ronpibon (Siam)	32	23	24½
Leeuwpoort (Transvaal)	71*	—	—
Mawready (Swaziland)	19*	—	—
Renong (Siam)	91	75	111
Rooiberg Minerals (Transvaal)	55	50	[illegible]
Siamese Tin (Siam)	124	134½	121
Tongkah Harbour (Siam)	98	123	113
Zaaiplaats (Transvaal)	10	—	—

* Three months. † Tributers.

Nigerian Tin Production.

In long tons of concentrate of unspecified content.

Note.—These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent [illegible] of the actual outputs.

	1916	1917	1918	1919	1920	1921
	Tons	Tons	Tons	Tons	Tons	Tons
January	531	667	678	613	547	478
February	[illegible]	646	[illegible]	623	477	370
March	747	655	707	606	[illegible]	445
April	486	555	584	546	467	394
May	536	509	525	483	383	337
June	510	473	492	484	435	423
July	[illegible]	479	545	481	484	[illegible]
August	498	551	571	616	447	377
September	535	538	[illegible]	561	528	—
October	584	578	491	625	628	—
November	679	621	472	536	544	—
December	654	655	518	511	577	—
Total	6,594	6,927	6,771	6,685	6,022	[illegible]

Production of Tin in Federated Malay States.

[illegible] at 70% of Concentrate shipped to Smelters. Long Tons.

	1917	1918	1919	1920	1921
	Tons	Tons	Tons	Tons	Tons
January	[illegible]	3,030	3,765	[illegible]	3,208
February	[illegible]	3,197	2,734	3,014	3,111
March	3,286	[illegible]	2,819	2,770	2,190
April	[illegible]	3,308	2,858	2,606	2,692
May	3,113	3,332	3,107	2,741	[illegible]
June	[illegible]	3,070	2,877	2,940	2,752
July	3,253	3,373	3,756	2,824	[illegible]
August	3,413	3,259	2,956	2,786	[illegible]
September	3,154	3,157	3,161	2,734	—
October	[illegible]	2,870	3,221	2,837	—
November	3,300	3,132	2,972	2,573	—
December	3,525	3,022	2,409	2,838	—
	[illegible]	37,370	36,935	34,928	25,172

Stocks of Tin.

Reported by A. Strauss & Co. Long Tons.

	July 31	Aug. 31	Sept. 30
Straits and Australian Spot	1,936	1,811	1,748
Ditto, Landing and in Transit	250	590	510
Other Standard, Spot and Landing	4,388	3,994	4,226
Straits, Afloat	1,355	1,025	2,000
Australian, Afloat	135	190	190
Banca, in Holland	4,244	4,003	3,934
Ditto, Afloat	351	897	[illegible]
Billiton, Spot	423	327	241
Billiton, Afloat	38	100	130
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	365	650	425
Total Afloat for United States	3,906	3,689	4,663
Stock in America	2,521	1,761	1,756
Total	19,852	19,037	20,777

Shipments, Imports, Supply, and Consumption of Tin.

Reported by A. Strauss & Co. Long tons.

	July	August	Sept.
Shipments from:			
Straits to U.K.	1,340	995	1,870
Straits to America	2,420	1,580	[illegible]
Straits to Continent	215	590	430
Straits to other places	325	950	615
Australia to U.K.	150	75	25
U.K. to America	975	490	390
Imports of Bolivian Tin into Europe	221	587	324
Supply:			
Straits	3,975	3,165	[illegible]
Australian	150	75	25
Billiton	55	275	[illegible]
Banca	1,284	[illegible]	1,085
Standard	1,228	928	811
Total	6,692	5,409	7,321
Consumption:			
U.K. Deliveries	1,224	2,004	1,707
Dutch ,,	321	289	329
American ,,	1.525	3 320	2,605
Straits, Banca & Billiton, Continental Ports, etc.	713	511	940
Total	3 793	6 224	5,581

Outputs Reported by Oil-producing Companies.

		June	July	August
Anglo-Egyptian	Tons	13,529	14,682	14,324
Anglo-United	Barrels	9,660	9,900	9,550
Apex Trinidad	Barrels	16,985	22,225	94,398
Astra Romana	Tons	22,358	22,234	27,013
British Burmah	Barrels	60,020	79,569	81,405
Caltex	Tons	—	13,340	—
Dacia Romana	Tons	236	236	—
Kern River	Barrels	91,157	93,421	66,061
Lobitos	Tons	8,845	9,323	9,169
Roumanian Consol	Tons	1,115	2,053	2,588
Santa Maria	Tons	1,228	1,371	1,286
Steaua Romana	Tons	17,704	18,730	22,760
Trinidad Leaseholds	Tons	11,300	18,892	11,800
United of Trinidad	Tons	3,402	2,983	4,291

Quotations of Oil Companies' Shares.

Denomination of Shares £1 unless otherwise noted.

	Sept. 6, 1921 £	s.	d.	Oct. 6, 1921 £	s.	d.
Anglo-American	4	0	0	4	0	0
Anglo-Egyptian B	1	10	0	1	2	6
Anglo-Persian 1st Pref.	1	1	6	1	1	3
Anglo-United, Wyoming		3	9		3	9
Apex Trinidad	2	0	0	1	13	9
British Borneo (10s.)		11	3		8	9
British Burmah (8s.)	1	0	0		17	6
Burmah Oil	5	15	0	4	17	6
Caltex ($1)		3	9		3	6
Dacia Romano	1	1	3		17	6
Kern River, Cal. (10s.)		18	6		19	3
Lobitos, Peru	3	17	6	4	0	0
Mexican Eagle, Ord. ($5)	5	2	6	3	10	0
,, ,, Pref. ($5)	4	17	6	3	7	6
North Caucasian (10s.)		16	3		13	9
Phœnix, Roumania		8	9		8	3
Roumanian Consolidated		11	0		8	6
Royal Dutch (100 gulden)	40	0	0	35	5	0
Scottish American		2	6		2	9
Shell Transport, Ord.	4	17	6	4	5	0
,, ,, Pref. (£10)	8	2	6	8	2	6
Trinidad Central	3	2	6	2	10	0
Trinidad Leaseholds	1	18	9	1	15	0
United British of Trinidad		16	3		13	9
Ural Caspian		16	3		12	6
Uroz Oilfields (10s.)		5	3		6	0

Dividends Declared by Mining Companies.

Date	Company	Par Value of Shares	Amount of Dividend
Sept. 15	Globe and Phœnix	5s.	1s. tax paid.
Sept. 14	British Aluminium	Ord. £1	5% less tax.
Sept. 16	Shamva	£1	7½% less tax
Sept. 16	Knight's Deep	£1	4s.*
Sept. 17	Kramat Pulai	£1	1s. less tax.
Sept. 17	Ivanhoe Gold	£5	1s. 6d. less tax.
Sept. 20	Gopeng Consolidated	£1	9d. less tax.
Sept. 22	Ferreira Deep	£1	7½% less tax.
Sept. 26	Talisman	£1	5s.†
Oct. 5	Ooregum Gold	Pr 10s. O 10s.	1s. 9d. less tax. 9d. less tax.
Oct. 6	Borax Consolidated	Pr £5 Or £5	6% less tax.
Oct. 8	Mexico of El Oro	£1	2s. 6d. tax paid

* Second distribution on liquidation. † First distribution on liquidation.

PRICES OF CHEMICALS. October 7.

These quotations are not absolute; they vary according to quantities required and contracts running.

		£	s.	d.
Acetic Acid, 40%	per cwt.	1	2	6
,, 80%	,,	2	5	0
,, Glacial	per ton	46	0	0
Alum	,,	16	0	0
Alumina, Sulphate	,,	14	10	0
Ammonia, Anhydrous	per lb.		2	2
,, 0·880 solution	per ton	28	0	0
,, Carbonate	per lb.			4
,, Chloride, grey	per ton	37	0	0
,, ,, pure	per cwt.	3	5	0
,, Nitrate	per ton	45	0	0
,, Phosphate	,,	75	0	0
,, Sulphate	,,	13	10	0
Antimony, Tartar Emetic	per lb.		1	6
,, Sulphide, Golden	,,		1	5
Arsenic, White	per ton	38	0	0
Barium Carbonate	,,	10	0	0
,, Chlorate	per lb.			11
,, Chloride	per ton	16	0	0
,, Sulphate	,,	8	0	0
Benzol, 90%	per gal.		3	0
Bisulphate of Carbon	per ton	56	0	0
Bleaching Powder, 35% Cl.	,,	16	0	0
,, Liquor, 7%	,,	6	0	0
Borax	,,	31	0	0
Boric Acid Crystals	,,	65	0	0
Calcium Chloride	,,	10	0	0
Carbolic Acid, crude 60%	per gal.		1	7
,, ,, crystallized, 40	per lb.			6½
China Clay (at Runcorn)	per ton	4	10	0
Citric Acid	per lb.		2	5
Copper, Sulphate	per ton	30	0	0
Cyanide of Sodium, 100%	per lb.			11½
Hydrofluoric Acid	,,			7½
Iodine	per oz.		1	0
Iron, Nitrate	per ton	8	0	0
,, Sulphate	,,	4	0	0
Lead, Acetate, white	,,	45	0	0
,, Nitrate	,,	47	0	0
,, Oxide, Litharge	,,	38	0	0
,, White	,,	44	0	0
Lime, Acetate, brown	,,	8	0	0
,, ,, grey 80%	,,	11	0	0
Magnesite, Calcined	,,	21	0	0
Magnesium, Chloride	,,	14	0	0
,, Sulphate	,,	8	0	0
Methylated Spirit 64 Industrial	per gal.		5	3
Nitric Acid, 80° Tw.	per ton	31	0	0
Oxalic Acid	per lb.			9
Phosphoric Acid	per ton	40	0	0
Potassium Bichromate	per lb.			10
,, Carbonate	per ton	26	0	0
,, Chlorate	per lb.			6
,, Chloride 80%	per ton	17	0	0
,, Hydrate (Caustic) 90%	,,	31	0	0
,, Nitrate	,,	49	0	0
,, Permanganate	per lb.		1	3
,, Prussiate, Yellow	,,		1	3
,, ,, Red	,,		2	3
,, Sulphate, 90%	per ton	16	0	0
Sodium Metal	per lb.		1	4
,, Acetate	per ton	30	0	0
,, Arsenate 45%	,,	44	0	0
,, Bicarbonate	,,	12	0	0
,, Bichromate	per lb.			7
,, Carbonate (Soda Ash)	per ton	15	0	0
,, ,, (Crystals)	,,	7	0	0
,, Chlorate	per lb.			4
,, Hydrate, 76%	per ton	26	15	0
,, Hyposulphite	,,	16	0	0
,, Nitrate, 96%	,,	18	0	0
,, Phosphate	,,	22	0	0
,, Prussiate	per lb.			7
,, Silicate	per ton	11	15	0
,, Sulphate (Salt-cake)	,,	6	10	0
,, ,, (Glauber's Salts)	,,	5	0	0
,, Sulphide	,,	22	0	0
,, Sulphite	,,	12	10	0
Sulphur, Roll	,,	13	0	0
,, Flowers	,,	13	0	0
Sulphuric Acid, Fuming, 65%	,,	24	0	0
,, ,, free from Arsenic, 144°	,,	6	5	0
Superphosphate of Lime, 30%	,,	6	10	0
Tartaric Acid	per lb.		1	6
Turpentine	per cwt.	3	9	0
Tin Crystals	per lb.		1	5
Titanous Chloride	,,		1	0
Zinc Chloride	per ton	22	10	0
Zinc Oxide	,,	41	0	0
Zinc Sulphate	,,	17	0	0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS	Oct. 7, 1920 £	s.	d.	Oct. 6, 1921 £	s.	d.
RAND:						
Brakpan	2	1	[illegible]	2	1	[illegible]
Central Mining (£8)	8	2	[illegible]	6	[illegible]	0
City & Suburban (£4)		7	6		[illegible]	[illegible]
City Deep	2	15	0	2	[illegible]	9
Consolidated Gold Fields	1	6	[illegible]		18	9
Consolidated Langlaagte		16	[illegible]		1[illegible]	0
Consolidated Main Reef		11	3		10	0
Consolidated Mines Selection (10s.)	1	1	3		15	[illegible]
Crown Mines (10s.)	2	11	3	2	0	0
Daggafontein		10	0		[illegible]	[illegible]
Durban Roodepoort Deep		5	[illegible]		[illegible]	6
East Rand Proprietary		9	[illegible]		5	3
Ferreira Deep		11	[illegible]		[illegible]	6
Geduld	1	10	3	2	[illegible]	0
Geldenhuis Deep		[illegible]	[illegible]		[illegible]	6
Government Gold Mining Areas	4	5	0	4	0	0
Johannesburg Consolidated	1	6	[illegible]	1	3	0
Kleinfontein		6	[illegible]		[illegible]	0
Knight Central		4	[illegible]		4	[illegible]
Knights Deep		6	0		[illegible]	
Langlaagte Estate		16	[illegible]		12	9
Meyer & Charlton	4	10	[illegible]	4	[illegible]	0
Modderfontein (10s.)	3	16	3	3	15	0
Modderfontein B (5s.)	1	13	[illegible]	1	6	3
Modderfontein Deep (5s.)	2	3	9	2	5	0
Modderfontein East	1	3	[illegible]		10	6
New State Areas	1	8	[illegible]	1	[illegible]	9
Nourse		10	3		9	6
Rand Mines (5s.)	2	15	0	2	6	3
Rand Selection Corporation	2	17	6	2	1[illegible]	6
Randfontein Central		14	9		11	0
Robinson (£5)		7	6		9	6
Robinson Deep A (1s.)		15	9		10	0
Rose Deep		18	6		13	3
Simmer & Jack		3	9		2	9
Springs	2	0	0	2	2	6
Sub-Nigel		17	6		12	6
Union Corporation (12s. 6d.)		17	6		1[illegible]	6
Van Ryn		16	[illegible]		11	9
Van Ryn Deep	3	17	6	3	15	0
Village Deep		10	6		8	3
West Springs		16	3		11	3
Witwatersrand (Knight's)		1[illegible]	[illegible]		12	6
Witwatersrand Deep		[illegible]	[illegible]		7	6
Wolhuter		4	9		4	3
OTHER TRANSVAAL GOLD MINES:						
Glynn's Lydenburg		13	9		7	6
Sheba (5s.)		1	[illegible]		1	6
Transvaal Gold Mining Estates		10	0		8	[illegible]
DIAMONDS IN SOUTH AFRICA:						
De Beers Deferred (£2 10s.)	17	0	0	11	0	0
Jagersfontein	4	5	0	2	7	6
Premier Deferred (2s. 6d.)	10	0	0	5	15	0
RHODESIA:						
Cam & Motor		12	0		9	6
Chartered British South Africa		15	9		11	[illegible]
Falcon		1[illegible]	6		5	0
Gaika		16	0		9	6
Globe & Phœnix (5s.)		17	[illegible]		13	6
Lonely Reef	2	16	3	2	7	6
Rezende	2	15	0	3	10	0
Shamva	1	13	[illegible]	1	11	[illegible]
Willoughby's (10s.)		[illegible]	[illegible]		4	3
WEST AFRICA:						
Abbontiakoon (10s.)		[illegible]	[illegible]		[illegible]	[illegible]
Abosso		11	0		8	9
Ashanti (4s.)		17	0		15	6
Prestea Block A		2	0		2	9
Taquah		13	6		8	6
WEST AUSTRALIA:						
Associated Gold Mines		3	[illegible]		2	3
Associated Northern Blocks		3	[illegible]		2	3
Bullfinch		3	[illegible]		1	0
Golden Horse-Shoe (£5)		1[illegible]	[illegible]		11	3
Great Boulder Proprietary (2s.)		7	0		[illegible]	6
Great Fingall (10s.)		1	[illegible]		1	6
Hampton Properties		1[illegible]	0		5	0
Ivanhoe (£5)	1	5	0		18	9
Kalgurli		16	[illegible]		13	3
Lake View Investment (10s.)		15	9		8	[illegible]
Sons of Gwalia		7	6		[illegible]	[illegible]
South Kalgurli (10s.)		[illegible]			6	6

GOLD, SILVER, *cont.*	Oct. 7, 1920 £	s.	d.	Oct. 6, 1921 £	s.	d.
OTHERS IN AUSTRALASIA:						
Blackwater, New Zealand		8	9		2	6
Consolidated G.F. of New Zealand		3	9		2	6
Mount Boppy, N.S.W. (10s.)		6	3		2	0
Progress, New Zealand		1	9		1	[illegible]
Waihi, New Zealand	1	12	6	1	2	6
Waihi Grand Junction, New Z'lnd.		10	0		5	9
AMERICA:						
Buena Tierra, Mexico		10	0		1	9
Camp Bird, Colorado		13	6		4	3
El Oro, Mexico		17	6		9	6
Esperanza, Mexico	2	5	0		17	6
Frontino & Bolivia, Colombia		8	9		6	3
Le Roi No. 2 (£5), British Columbia		5	0		2	6
Mexico Mines of El Oro, Mexico	7	7	6	4	7	6
Nechi (Pref. 10s.), Colombia		8	9		4	0
Oroville Dredging, Colombia	1	7	6	1	2	6
Plymouth Consolidated, California	1	0	0		10	0
St. John del Rey, Brazil		15	0		16	0
Santa Gertrudis, Mexico	1	1	6		7	6
Tomboy, Colorado		10	0		5	0
RUSSIA:						
Lena Goldfields	1	0	0		7	6
Orsk Priority		10	0		5	0
INDIA:						
Balaghat (10s.)		8	6		5	0
Champion Reef (2s. 6d.)		2	6			6
Mysore (10s.)		15	6		12	3
North Anantapur		4	6		5	0
Nundydroog (10s.)		7	6		6	9
Ooregum (10s.)		13	9		13	0
COPPER:						
Arizona Copper (5s.), Arizona	2	3	9		17	6
Cape Copper (£2), Cape and India	1	0	0		12	6
Esperanza, Spain		5	0		5	0
Hampden Cloncurry, Queensland		13	9		6	3
Mason & Barry, Portugal	1	10	0	2	0	0
Messina (5s.), Transvaal		5	6		3	6
Mount Elliott (£5), Queensland	1	5	0		11	3
Mount Lyell, Tasmania	1	2	0		12	6
Mount Morgan, Queensland		18	6		12	6
Namaqua (£2), Cape Province	1	10	0		15	0
Rio Tinto (£5), Spain	29	10	0	25	10	0
Russo-Asiatic Consd., Russia		12	0		7	6
Sissert, Russia		11	3		5	0
Spassky, Russia		17	6		8	9
Tanganyika, Congo and Rhodesia	1	12	6	1	0	0
LEAD-ZINC:						
BROKEN HILL:						
Amalgamated Zinc	1	6	3		16	3
British Broken Hill	1	15	0		18	9
Broken Hill Proprietary	2	10	0	1	13	9
Broken Hill Block 10 (£10)	1	1	3		10	0
Broken Hill North	2	6	3	1	8	9
Broken Hill South	2	6	3	1	5	0
Sulphide Corporation (15s.)		16	3		11	0
Zinc Corporation (10s.)		16	3		17	6
ASIA:						
Burma Corporation (10 rupees)		12	6		6	0
Russian Mining		10	0		5	0
RHODESIA:						
Rhodesia Broken Hill (5s.)		11	0		5	6
TIN:						
Aramayo Francke, Bolivia	3	2	6	1	12	6
Bisichi (10s.), Nigeria		10	0		5	0
Briseis, Tasmania		4	3		2	6
Dolcoath, Cornwall		3	0			9
East Pool (5s.), Cornwall		8	9		3	0
Ex-Lands Nigeria (2s.), Nigeria		2	9		1	3
Geevor (10s.), Cornwall		10	0		2	6
Gopeng, Malay	1	17	6	1	12	6
Ipoh Dredging, Malay		15	0		19	0
Kamunting, Malay	2	10	0	1	3	9
Kinta, Malay	2	0	0	1	12	6
Malayan Tin Dredging, Malay	1	15	0	1	1	3
Mongu (10s.), Nigeria		17	6		10	0
Naraguta, Nigeria		11	3		12	6
N. N. Bauchi, Nigeria (10s.)		3	[illegible]		2	0
Pahang Consolidated (5s.), Malay		10	6		5	6
Rayfield, Nigeria		8	0		2	6
Renong Dredging, Siam	2	3	9	1	[illegible]	9
Ropp (4s.), Nigeria		8	6		6	0
Siamese Tin, Siam	3	5	0	1	17	6
South Crofty (5s.), Cornwall		12	0		3	6
Tehidy Minerals, Cornwall		15	0		5	0
Tekka, Malay	1	2	[illegible]		17	6
Tekka-Taiping, Malay	1	1	3	1	[illegible]	0
Tronoh, Malay	1	11	3	1	5	0

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also notices of new books and pamphlets, lists of patents on mining and metallurgical subjects, and abstracts of the yearly reports of mining companies.

STUDIES OF TRANSVAAL TIN DEPOSITS

Memoir No. 16 of the Geological Survey of the Union of South Africa deals with the tin-mining district between Warmbaths and Lydenburg in the Northern Transvaal. The deposits are just north of the junction of the Elands and Olifants rivers, and are some distance away from the better known tin-mining district north-west of Warmbaths. The Memoir is written by Dr. Percy A. Wagner, who was appointed three years ago by the Geological Survey to make special investigations. The tin-mining district, which is the subject of this report, contains producing mines, operated by the Mutue Fides (Transvaal) Consolidated Land and Exploration Co., the Stavoren Tin Mines Co., the Olifants Tin Mines Co., and the Union Tin Mines Co. The particulars of the deposits are not of great interest from the point of view of production, but Dr. Wagner's studies afford him an opportunity of joining in the discussion of the problem of the origin of tin ores. He says the district gives a grand chance to the mineralogist to collect specimens of a great variety of minerals, but this chance is shared by students of Cornish mines. As we have often remarked, the reports on Cornish and other mines seldom make reference to the existence of any but the leading economic minerals, and the mineralogist desirous of discussing origins is usually unable to make any useful deduction until he makes a personal visit. Mineralogists will therefore welcome Dr. Wagner's voluminous report on these deposits. We make quotations from the report, not for the object of giving a description of the deposits, but for the purpose of publishing Dr. Wagner's views as to the origin of the ores.

The mineral deposits are not restricted to any definite horizon or formation occurring in the red granite, the granophyric granite above the normal granite, the granophyre, the granitic rocks above the granophyre, and in the basal quartzites of the Waterberg System. The deposits are all essentially replacement deposits connected with more or less well-defined fractures and joint-planes, cavity filling having played a quite subordinate rôle in their formation. It should be stated that the mineralizing fractures, as a rule, are mere cracks that do not themselves carry ore. The occurrences are as numerous as they are varied, and present such an extraordinary diversity of type that it is difficult to arrive at a satisfactory basis of classification. It is found, however, that the deposits in each of the geological divisions enumerated have more or less well-marked characteristics, particularly in regard to the assemblages of metallic minerals present and the character of the alteration of the wall-rocks. It is proposed to classify them according to the nature of the rock in which they occur, as follows: (1) Deposits in granite; (2) deposits in granophyric granite; (3) deposits in granophyre; (4) deposits in the zone of granitic rocks above the granophyre; (5) deposits in quartzite. It is not to be inferred from this classification that the nature of the wall-rock has been the principal factor in determining the characteristics of the several types of deposit, though it undoubtedly has had some influence. The main cause of the observed differences lies in the fact that, since the various rocks named are regularly super-imposed and the metalliferous vapours and solutions that gave rise to the formation of the deposits undoubtedly travelled upward, each of the divisions represents a certain thickness of rock that had to be traversed before the solutions (gaseous and liquid) could deposit their load. The kind of country rock is thus correlated with the conditions of temperature and pressure under which the mineralization took place. The deposits in granite, which are the lowest topographically as well as geologically, were evidently formed at the highest temperature and pressure, and those in the quartzite at the lowest temperature and pressure, while the deposits in the other rocks were formed at temperatures and pressures intermediate between those obtaining in the case of the deposits in granite and quartzites. These conclusions are in consonance with what is known in regard to the relative temperatures of formation of the principal ore minerals present in the different occurrences, recent investigations having proved that cassiterite is a higher temperature mineral than wolframite or scheelite, and that these in turn are deposited at higher temperatures than chalcopyrite. Thus, the deposits in granite are essentially tin deposits, cassiterite being the only mineral recovered. Wolframite and chalcopyrite are also present, but only in subordinate quantities. The deposits in granophyric granite are cassiterite-scheelite deposits, both minerals occurring in workable quantity. The deposits in granophyre are cassiterite-scheelite-chalcopyrite deposits, scheelite being often more abundant than cassiterite, while in some occurrences chalcopyrite is in excess of both. The deposits also carry bismuth minerals which were not noted in the other classes of deposit. The deposits so far opened up in the granitic rocks above the granophyre yield cassiterite, copper ores, and wolframite. The deposits in the quartzite are also cassiterite-chalcopyrite-wolframite deposits characterized by containing considerable quantities of specularite, which almost without exception is greatly in excess of the economic minerals present. It remains to be stated that, as regards their ore content, the deposits are extraordinarily erratic and, in consequence, difficult and expensive to work, their exploitation having, on the whole, been attended with disappointing results.

The ore occurrences of the area yield a rich and varied assortment of minerals. In all fifty minerals were identified, some of them for the first time in South Africa. For convenience in description the author divides them into primary ore-minerals, secondary ore-minerals, and gangue minerals

[illegible] important of the ore-minerals. The crystals range in size from [illegible] to [illegible] diameter of 1½ inch, very large crystals occurring in some of the pegmatite [illegible] on the farm Mutue Fides and in certain of the occurrences on the farm Stavoren. The mineral is also found in irregular masses. The colour of the crystals varies considerably, the prevailing tints being yellowish-brown and brown. On the farm Stavoren the cassiterite of the Spruit working is of a pale resin colour, that of the Hillside Quarry is reddish-brown, and that of the "C" and "D" occurrences dark-brown or chocolate coloured. The Joe's Luck working on Roodewal yields translucent crystals of pale-purplish colour of the variety known as "ruby tin."

The presence of stannine in the pyritic ore of the wolfram pipe on Stavoren is inferred from the fact that, whereas the ore can be shown by analysis to contain small amounts of tin, no cassiterite is to be detected in it either in the pan or under the microscope.

Primary scheelite is, after cassiterite, the most important ore-mineral. It is confined to the occurrences in granophyre and in the immediately underlying granophyric granite. It occurs in well-formed square bipyramids resembling octahedra, and also in irregular grains and masses. The crystals often attain large dimensions ranging up to 3¼ in. across, while crystals from 1 in. to 1½ in. across are quite common. The scheelite taken from and near the outcrops of the ore-bodies sometimes shows alteration to tungstite. More usually, however, the crystals and grains present a curiously etched and corroded appearance, and there can be no question that the mineral is susceptible to alteration under the influence of the atmospheric agencies. The occurrence of secondary scheelite may here be referred to, since the mineral is not secondary in the sense that tungstite and certain copper minerals are secondary. It occurs in narrow veinlets and stringers, and also in well-formed crystals in the wolframite of certain of the deposits on the farm Mutue Fides, having been derived from the alteration of that mineral, probably through the agency of heated magmatic waters holding calcium in solution. The scheelite differs from the primary scheelite in being of grey or greyish-white colour, whereas the latter ranges in colour from yellowish-grey to yellowish-brown.

Iron-rich wolfram is sparingly present in some of the deposits in granite on the farm Mutue Fides, where it occurs in masses, some of which are as large as a man's fist. The crystal faces, where present, are generally striated in characteristic fashion. The wolframite from most of these occurrences presents a greyish appearance owing to the presence of numerous minute veinlets of secondary scheelite, which follow the cleavage planes of the mineral and occupy irregular cracks. In the wolframite pipe situated in the upper zone of granitic rocks on the farm Stavoren the mineral occurs in blackish-brown masses up to ¾ in. across. In outcrop specimens of wolframite ore the mineral is generally found to be covered with a rough blackish-brown cellular crust, proving that it also is susceptible to atmospheric weathering. Occasionally the crystals are completely replaced by a dark-coloured porous cindery mass composed entirely of iron and manganese oxides. This form of alteration implies the removal in solution of the tungstic oxide originally present. It has been recorded in the Laxey deposit of Lower Burma by Morrow Campbell, who attributes it to the simultaneous action of alkaline water and oxygen.

Chalcopyrite is the only primary copper mineral hitherto identified in the deposits. It has a very wide distribution, and is present in practically all the important occurrences so far opened up. It is most abundant in the deposits in granophyre, in which it is frequently present in sufficient quantity to repay extraction. There is also an important occurrence of chalcopyrite in quartzite on the farm Roodewal. The oxidation of the chalcopyrite occurring in the superficial portions of many of the deposits, and the downward migration of solutions derived from its decomposition, have given rise to a large and interesting assemblage of secondary copper minerals.

Pyrite is abundant in the deposits in granite, pyritization having next to sericitization been the most important metasomatic process involved in their formation. It is less abundant in the deposits in granophyre, where it is subordinate to arsenopyrite, but is also apparently abundant in the deposits in quartzite, judging by the amount of secondary martite and limonite present in the gossans of these deposits. In the pyritic stanniferous greisen of the Mutue Fides mine the mineral is found in crystals of octahedral habit, while in the chloritic ore of the same occurrence it is present in bright pentagonal dedocahedrons of brass-yellow colour. In the lower levels of the Union tin mines pyrite occurs in fine-grained aggregates composed of small interlocking masses.

Arsenopyrite has a wide distribution in the deposits in granite and granophyre, but has not so far been recorded from any of the occurrences in quartzite. It occurs in well-formed crystals, in irregular prismatic individuals, and finally massive. The arsenopyrite of the arsenic working on the farm Stavoren contains small amounts of cobalt, which is probably present as glaucodote (FeCo)AsS. In some of the Stavoren deposits arsenopyrite is so abundant that it was found practicable to erect a plant for the recovery of arsenious oxide, which was successfully operated during the war. The mineral is also very abundant in the lower levels of the Mutue Fides mine.

Molybdenite is fairly common in the occurrences in granophyre and was also noted in one of the workings in granite on the farm Mutue Fides. It occurs in bright bluish metallic flakes, in aggregates of such flakes, and also in lamellar masses. It is particularly abundant in the aureoles of raven-mica surrounding some of the pipes and eyes on the farm Stavoren. From one of the workings several tons of picked molybdenite ore were actually recovered.

Specularite is fairly abundant in some sections of the Mutue Fides mine and very abundant in many of the workings in quartzite on the farms Roodewal and Stavoren. In the Mutue Fides mine and certain sections of the Union tin mine it occurs in the form of ordinary lustrous micaceous hematite, but most of the occurrences in quartzite yield a dull black variety of the mineral.

Galena occurs in minor quantities in the pyritic tin ore of the Mutue Fides mine in association with zinc-blende, chlorite, fluor-spar, and calcite. It is the product of a later period of metallization than the cassiterite and associated minerals. It is also found in several of the occurrences on Stavoren. Here the mineral occurs partly in large well-formed crystals—combinations of the cube and octahedron—and

partly in irregular masses associated with beautifully coloured violet and bluish-violet fluor-spar. The galena at one of the workings on Stavoren contains up to 50 oz. of silver per ton.

Other primary minerals mentioned by Dr. Wagner in his paper are zircon, magnetite, bismuthinite, galeno-bismutite, blende, and graphite. The secondary ore-minerals mentioned are tungstite, cuprotungstite, scorodite, bismutite, chalcocite, covellite, bornite, native copper, malachite, azurite, cuprite, tenorite, chrysocolla, chalcanthite, olivenite, cerussite, martite, and limonite. The gangue minerals are quartz, chalcedony, felspar, raven-mica, tourmaline, fluor-apatite, sericite, kaolin, lithomarge, chlorite, fluor-spar, calcite, and ankerite. Raven-mica is the rabenglimmer of Saxony, and it is found also at St. Just, Cornwall; it is a lithium-potassium-iron mica.

One of the most noticeable features of the various occurrences is the constant and intimate association of cassiterite with quartz. The mineral is almost invariably found enclosed or partially embedded in the earlier quartz where it has not completely replaced it, and though often found replacing felspar there can be no question that in a great majority of cases the cassiterite has selectively replaced the quartz in preference to felspar. This is very noticeable in certain of the occurrences in granite, in which the original quartz of the rock has been almost completely replaced by cassiterite, whereas the felspar, except where partially sericitized, is unaltered. It was also observed frequently in the deposits in granophyre and in the deposits in quartzite. In explanation of the phenomenon it may be pointed out that tin and silicon are very closely allied, both belonging to the carbon group in the periodic classification, so that one would expect the compounds of the two elements to be intimately associated in nature. Even more important, however, is the fact that cassiterite and quartz have practically the same molecular volume, 21·9 in the case of the former as against 22·8 in the case of the latter. The replacement of quartz by cassiterite in preference to felspar would thus involve a minimum expenditure of energy.

Emphasis is laid by Dr. Wagner on the important rôle played in the formation of the mineral deposits by fissures and joint planes. No distinction is made between these, as the more pronounced fissures appear to be of the nature of master joints. Fissures trending in all directions are met with in the several types of country rock, but only those trending in certain directions are ore-bringers, the productive fissures being clearly those that were accessible to the metalliferous vapours and solutions at the time of mineralization. A knowledge of what directions of fissuring are favourable and what directions are unfavourable is thus of the utmost importance to those engaged in the search for new deposits in the area, whether in virgin ground or in the workings of the existing mines. The author gives the results of his observations in this connexion.

Dr. Wagner then discusses the origin of the mineral deposits. The first point relates to the source of the metalliferous vapours and solutions that gave rise to the deposits. In regard to this point it is evident that the deposits are connected genetically with the intrusion of the main mass of the Bushveld granite, and since some of them pass without interruption from the granite into the overlying rocks and in the deposits in granite all the evidence points to the prevalent direction of movement of the mineralizing solutions (gaseous and liquid) having been upward, the source of these is clearly to be sought in some deep-seated and probably at the time incompletely consolidated zone of the granite underlying the mineralized area. Whether the metals contained in the solutions were extracted from the granite by the agency of mineralizers, as has been suggested for certain tin deposits by Vogt, or whether they represent primary constituents of the mother liquor of that rock, is not relevant to the question at issue, since, as Taber has pointed out, there is no essential difference between (1) the transfer of ore-minerals through the agency of mineralizers set free during the final stages of the consolidation of an igneous magma and (2) the solution and transportation by mineralizers of the metallic minerals originally dispersed through a rock-mass. The N.N.E.–S.S.W. and N.E.–S.W. fissures in the granite appear to have been the only channels that had direct access to this deep-seated zone in the granite. From them the solutions were fed into the W.N.W.–E.S.E. and N. by W. fissures in the overlying rocks in which all four sets were ore-bringers.

The formation of the pegmatites, in which some of the ore-bodies occur, and the deposition of the various ore and gangue minerals clearly represent successive stages in the final phase of consolidation of the Red Granite, the progressive change in the chemical nature of the magmatic emanations having been clearly coincident with a progressive decrease in their temperature. It is now generally recognized that the crystallization of pegmatites involves the co-operation of water and other mineralizers, and takes place at temperatures not far removed from 575° C., the crystallographic inversion-point of quartz. This may be taken to represent the upper temperature limit in so far as the mineral deposits are concerned, since it is improbable that the temperature at any subsequent stage exceeded that prevailing during the formation of the pegmatites; an inference that would agree with the conclusion tentatively reached in regard to the quartz of the second generation in the deposits in the granophyre, namely, that it is α quartz which crystallized below 575°. Of the earlier-formed ore-minerals specularite—the only metallic mineral present that has been proved in any of the deposits to be older than cassiterite—cassiterite, wolframite, molybdenite, and scheelite, are all characteristic of deposits formed at high temperatures. It may be safely concluded, therefore, that the temperature during the deposition of these minerals was well above the critical temperature of water, namely, 358° C. They must thus have been deposited from gaseous solutions, or, in other words, under pneumatolytic conditions, using the term "pneumatolytic" in its strictest sense. Following Iddings and McDonald this period of mineralization may be referred to as the secondary pneumatolytic phase to distinguish it from the primary pneumatolytic or pegmatitic phase during which the pegmatites were formed. Raven-mica, tourmaline, and quartz (second generation) are also assigned to the secondary pneumatolytic phase, but to an earlier stage than the ore-minerals

The next phase of mineralization, during which chlorite, sericite, quartz, pyrite, and chalcopyrite were deposited, has all the characteristics of hydrothermal metasomatism at moderate temperatures. It is not known whether the

[illegible] during this period exceeded the critical [illegible] of water. It is possible, however, that the temperature may have been above 358° at the beginning of the period and below 358° at the end of the period, which would imply a change in the state of the solutions from gaseous to liquid. To this phase the designation "early hydrothermal" may be applied. It corresponds with the propylitic phase which McDonald has distinguished in the phase of the Leeuwpoort lodes. During the fourth phase of primary mineralization, in which galena, bismuthinite, blende, fluor-spar, calcite, and chalcedony were deposited by heated aqueous solutions, fairly low temperatures—probably not far removed from 150° C.—must have prevailed. It may be referred to as the "late hydrothermal phase" and corresponds with McDonald's phase of carbonitization.

Through being brought by denudation into the zone of weathering all the deposits have suffered secondary alteration by oxygenated surface waters, with the resultant formation of oxides, carbonates, secondary sulphides, kaolin, and chlorite. In certain of the deposits these changes, which are in progress at the present day, have been attended with very important results. This final phase will be referred to as the "phase of alteration" by cold descending meteoric waters.

Correlating the successions of the ore and gangue minerals in the several types of deposit with what has been stated in regard to the physical conditions prevailing during the different periods of mineralization, the history of the deposits may be summarized as given in the accompanying table:—

		Prevailing Temperature.
Pegmatitic or Primary Pneumatolytic Phase.	Deposition of pegmatitic felspar and quartz, or pegmatitic felspar alone.	About 575° C.
Secondary Pneumatolytic Phase.	*Stage I.*—Deposition of raven-mica, quartz, and probably tourmaline. *Stage II.*—Deposition of specularite, cassiterite, wolframite, molybdenite, scheelite, arsenopyrite, and fluor-apatite.	<575° C. >358° C.
Early Hydrothermal Phase.	Deposition of chlorite, sericite, quartz, pyrite, chalcopyrite, some fluor-spar, and probably bismuthinite.	
Late Hydrothermal Phase.	Deposition of galena, zinc-blende, fluor-spar, ankerite, calcite, quartz, chlorite, and probably secondary scheelite.	About 150° C.
Phase of Alteration by cold descending Meteoric Waters.	Formation of chalcocite, covellite, copper oxides, bismutite, tungstite, cerussite, martite, limonite, kaolin, and secondary chlorite.	Ordinary atmospheric temperature.

It is of great interest to record that the first four phases, which, as indicated, are practically the same as those made out by McDonald in the lodes of the Leeuwpoort tin mine, also correspond very closely with the four periods of crystallization that Brögger discriminates in the pegmatite dykes of the Christiana region, namely:—

(1) The phase of magmatic consolidation during which the essential minerals of the pegmatites crystallized.
(2) The principal pneumatolytic phase.
(3) The phase of zeolite formation.
(4) The phase of carbonate and fluo-carbonate deposition.

It appears not improbable that on further investigation most tin-tungsten-copper deposits will be found to have much the same history as those under review, but it will probably rarely be so easily and completely decipherable. The confusion that has arisen in the past in regard to the respective rôles of pneumatolysis and hydatogenesis in the formation of such deposits has been due to failure to recognize that in a great majority of cases there have been successive periods or phases of ore deposition, each characterized by certain assemblages of minerals, the different phases probably corresponding with definite ranges of temperature.

While there can be little doubt that the later-formed ore-minerals (pyrite, chalcopyrite, bismuthinite, galena, and blende) were deposited by the agency of heated magmatic waters, there is considerable uncertainty in regard to the nature of the vehicle or carrier that was responsible for the introduction of cassiterite, scheelite, and wolframite. The intimate association of cassiterite with fluo- and boro-silicates in many of the classical tin deposits of the world, coupled with the experimental proof by Daubree and Deville and Carron that at red heat the vapours of stannic chloride and stannic fluoride can be decomposed by steam with the deposition of cassiterite, led to the development of the well-known pneumatolytic theory, according to which cassiterite is generally introduced in the form of volatile stannic fluoride. It must be admitted that where fluorine and boron minerals are abundantly present this theory accords admirably with all the observed facts. Of recent years, however, a number of important tin-tungsten deposits have engaged the attention of geologists, in which topaz, tourmaline, and allied minerals are conspicuous by their entire absence or their extreme rarity. The Mutue Fides–Stavoren deposits belong to this category.

Coggin Brown and W. R. Jones, in discussing the origin of the deposits of Tavoy in Lower Burma, which in their more typical development contain neither topaz nor tourmaline, have independently suggested that the place of fluorine may have been taken by sulphur and arsenic. More recently Morrow Campbell has suggested in respect of the same deposits that highly siliceous heated water (he speaks of a quartz-water mixture) was the carrier of both wolframite and cassiterite. In support of this contention he quotes Verbeeck, who refers to a hot spring in Malacca that deposits siliceous sinter containing 0·5% SnO_2; and also points to

the existence of a compound known as silicotungstic acid (SiO_2, $4H_2O$, $12WO_3$) which is readily soluble in water. Campbell brings forward no absolutely conclusive evidence in support of his views. He assumes, for example, that the same agencies that brought about the greisenization of the granite surrounding the Tavoy veins introduced the cassiterite and wolframite, but gives no reasons for believing such to have been the case. This is the very point in regard to which uncertainty prevails in the case of the Mutue Fides–Stavoren deposits. Extensive greisenization or sericitization has here taken place, presumably through the agency of heated water, but the main period of sericitization post-dated the introduction of the earlier ore-minerals, and there is, as already pointed out, no evidence to show that the deposition of cassiterite was accompanied by sericitization. The only fluorine minerals present in the Mutue Fides–Stavoren are fluor-apatite and fluor-spar. The latter was only introduced at a comparatively late stage in the formation of the deposits and may thus be ruled out. Fluor-apatite, on the other hand, which is sparingly present in some of the deposits, appears to have been formed contemporaneously with the earlier minerals, proving that fluorine compounds were active at this stage in the formation of the deposits, and incidentally affording evidence in support of the commonly accepted pneumatolytic theory. Then, again, specularite, which occurs in several of the deposits in granite and is very abundant in the deposits in quartzite, is known to be readily formed by the interaction between ferric chloride in the vapour state with steam, whereas the direct replacement of quartz by specularite which is frequently observed would be very difficult to explain on the supposition that the iron had originally been in aqueous solution. To the absence of tourmaline the author attaches little importance, for in his experience the association of cassiterite and tourmaline, as a rule, is purely accidental, the latter mineral being generally of earlier introduction. In some deposits, however, boron appears to have been the active agent. Thus, in the remarkable tin occurrences of the Seward Peninsula, Alaska, described by Knopf, boron is actually combined with tin in the rare minerals paigeite and hulsite, while boro-silicates and other boron minerals are abundantly present.

Whatever the nature of the vehicle, it is quite clear that it was capable of reacting very readily and vigorously with quartz and felspar, since even where, as appears frequently to have happened, cassiterite was deposited in crystals of quartz and felspar in drusy cavities, it is never merely found encrusting these minerals, but is always partially embedded in them, and in numberless instances there is evidence of its having replaced them. The cassiterite was thus evidently deposited as a result of mutual chemical reaction between the compound in which the tin was contained and quartz and felspar. It is quite possible that the compound was stannic tetrafluoride and that the cassiterite was deposited by the direct action between it and quartz according to the equation—

$$SnF_4 + SiO_2 = SnO_2 + SiF_4,$$

since Daubree was able to synthesize cassiterite by the action of stannic chloride ($SnCl_4$) vapour on heated lime. If this reaction was responsible for the deposition of the cassiterite, it is remarkable that no topaz was formed in the case of the felspar, and that the stanniferous greisen of the Mutue Fides mine contains not a trace of fluorine. It may have been, however, that the physical conditions prevailing may not have been suitable to the formation of topaz or other fluo-silicates and that the silicon tetrafluoride, which is a gas, passed upward, together with any other gaseous fluorides that may have been formed, and gave rise in the originally overlying rocks at a higher level and at a much lower temperature to the formation of fluor-spar. Much the same reasoning would apply to the scheelite and wolframite, for tungsten also forms a fluoride WF_6 with a boiling point of only 19° C., so that it is a gas at ordinary temperatures. The theory outlined appears, at any rate, to be quite as plausible as that of Campbell, which would make a heated aqueous solution of silica the carrier, for if cassiterite had been deposited by a solution of this nature it would be very difficult to explain the occurrence of the mineral embedded in absolutely fresh and unaltered orthoclase, when it is well known that the latter is very readily attacked by solutions of the nature postulated. Further work will doubtless throw more light on this vexed question, which in the present state of our knowledge it would be idle to pursue.

Dr. Wagner passes to the consideration of vertical ranges of the economic minerals and the prospects of their persisting at depth. The lowest deposits geologically are those in granite on the farm Tygerpad No. 2,300, and the highest geologically as well as topographically those in quartzite on the farm Kwarriehoek No. 1,818. Assuming that the quartzite-granite contact originally extended northward to a point vertically above the Tygerpad workings at the same inclination at which it is seen to dip southward below the Makeckaan plateau, an assumption the propriety of which is open to serious question, then the deposits at present known would represent a vertical range of about 2,700 ft. Of the various ore-minerals present, cassiterite, wolframite, chalcopyrite, pyrite, and specularite have the greatest vertical range, being found throughout the whole series of deposits from those in granite to those in quartzite. The vertical range of the primary scheelite, on the other hand, is limited. It has not been observed in any of the deposits in granite, quartzite, or the upper zone of granitic rocks, and appears to be confined to those in granophyre and granophyric granite. The lowest deposits in which the mineral occurs are those in the Acre Patch workings on Gaasterland, and the highest are the "B. 1" pipes on Stavoren, the difference in level between the outcrops of these deposits being 415 ft. The actual vertical extent of the scheelite, which is evidently very much greater, unfortunately cannot be calculated owing to the uncertainty as to the angle at which the granophyric-granite granophyre contact originally extended northward, and the fact that nothing is known in regard to the downward limit of the scheelite in the granophyric-granite.

Arsenopyrite has so far not been recorded from any of the deposits in quartzite and the same applies to galena and blende. In how far this is due to the fact that only one deposit in quartzite has been worked to even a moderate depth is not clear. Had any of the minerals named been present in considerable quantities in the deposit so far opened up it could, however, hardly have escaped detection.

A very important problem relates to the depth to which the cassiterite is likely to persist. In

[illegible] very little light upon. The investigations of Malcolm Maclaren on the tin mines of Cornwall have placed it beyond reasonable doubt that temperature is the governing factor in the deposition of the mineral, which is evidently only formed within certain definite limits of temperature. These limits correspond in each case with a definite vertical range, which would clearly be determined in turn by the temperature gradient in the enclosing rocks at the time of deposition; so that the temperature gradient really determines the limits within which cassiterite is precipitated from ascending gaseous solutions. [This view has been put forward independently by Morrow Campbell in the paper entitled "The Origin of Primary Ore Deposits," read before the Institution of Mining and Metallurgy in October, 1920. Chapter VI of the present Memoir was written in May, 1920.] In some of the Cornish mines the vertical ranges of cassiterite and the other ore-minerals present have been fairly accurately determined. In the area with which we are dealing the only mineral concerning which anything is known in this respect is scheelite, and even as to its vertical extent there is complete uncertainty. In regard to the range of the cassiterite nothing is known. It may safely be assumed, however, since the metalliferous solutions travelled upward and the temperature gradient was probably fairly uniform throughout, that within the limits previously indicated, the higher a deposit is situated geologically the greater is the depth below its outcrop to which cassiterite is likely to extend. In other words, as regards their persistence at depth, the deposits in the rocks above the Red Granite are more favourably placed than those in that rock. This does not, of course, imply or postulate that a deposit opened up, say in the upper portion of the granophyre, will be found to carry ore continuously all the way to the underlying granite, and then extend downward in that rock, but refers merely to the vertical range of the mineralization. Even in the granite, however, prospects of the tin persisting at depth are favourable, if one may argue by analogy with the only tin-tungsten-copper deposits that have so far been worked to considerable depths, namely, those of Cornwall. In the Cornish deposits it has been established definitely that primary depth zones exist. In the East Pool mine, for example, the downward succession of the economic minerals is roughly as follows: copper ores from the surface to 140 fathoms; wolframite from 140 fathoms to 200 fathoms; and cassiterite from 140 fathoms to 340 fathoms in the south-dipping lodes and possibly to 450 fathoms in the north-dipping lodes. The copper zone is thus succeeded by a tungsten-tin zone and this by a tin zone. In a more recent report on the central mines of the Camborne–Redruth area Maclaren, summarizing his views on the limits in depth of profitable tin-working in that district, points out that in most instances there is a marked falling off in tin-content at an average depth below the granite-killas contact of about 200 fathoms, or some 360 fathoms below the surface; only in one case, the well-known Dolcoath ore-body, did productive ore extend much below this; even this has failed at about the 500 fathom level.

If the same zones exist in the area under review, then it is clear that the Mutue Fides–Tygerpad deposits are near the bottom of the tin-tungsten zone and have not even entered the tin zone proper. It is also relevant to observe that the Zaaiplaats deposits of the northern Waterberg tinfields, which appear to be situated at an even lower horizon with regard to the source of the metalliferous vapours than the Mutue Fides deposits, have been worked to a vertical depth of over 400 ft. As the greatest vertical depth so far attained in any of the workings in granite in the Mutue Fides area is only 135 ft., there is thus every likelihood of the cassiterite persisting far below the limits so far reached. Here again, however, there is absolutely no assurance as to the continuity or workability of any particular occurrence at depth, for the deposits in granite are quite as erratic as those in the overlying rocks. The extraordinary patchiness of deposits of this type is to be attributed to the fact that the principal ore-minerals were introduced by gaseous solutions that travelled along narrow joints and fissures under high pressure and apparently rushed from point to point where favourable conditions to deposition offered, leaving the intervening stretches absolutely barren. The conception of the deposition having taken place from gaseous solutions under high pressure will also serve to explain how very considerable quantities of cassiterite could have been introduced from what in many instances are mere cracks.

As regards depth at which the mineralization took place, the present topography of the tinfields probably bears no relationship whatsoever to that in existence when the deposits were formed. At that time the area was covered with a considerable thickness of sedimentary and igneous rocks belonging to the lower division of the Waterberg System. What the thickness of these rocks may have been there is no means of ascertaining. The thickness of the basal or Rooiberg series in the Makeckaan plateau is about 1,200 ft., and that of the overlying volcanic series of the Waterberg System about 800 ft. This, however, probably only represents a small part of the original thickness of the volcanic series, which in the Middelburg District of the Transvaal, where it attains its maximum development, has a thickness of 8,000 ft. It appears unlikely for various reasons that the volcanic beds were ever anything like so thick in the area with which we are dealing, but there is no positive evidence that they were not. All that can thus be said in regard to the depth of cover at the time of mineralization is that it was not more and in all probability considerably less than 9,000 ft.

It has been shown that the mineral deposits are later than the quartzites and conglomerates of the Makeckaan plateau, which have been correlated with the Rooiberg series, the lowest member of the Waterberg System. The evidence available in the area under review does not enable one to assign more accurate limits to the period in which they were formed. There can be no question, however, that the deposits are products of the epoch of widespread mineralization, following the intrusion of the main mass of the Bushveld granite.

It remains to inquire why the mineral deposits should be situated where they are in a zone about 3 miles wide striking in an N.N.W.–S.S.E. direction. In regard to this question there is nothing definite to go upon and it would be idle to discuss it. The fact that tin-tungsten deposits the world over are connected with anticlinal and domal structures suggests, however, that the position of the mineral belt may have been determined by an anticline in the originally overlying Waterberg beds.

THE NORTHAMPTON LEAD DISTRICT, W.A.

On several occasions the lead-mining operations in the Northampton district, West Australia, have been the subject of articles or notices in our pages, the last occasion being in March, 1919. The properties have been worked for many years by the Fremantle Trading Company, which is allied to the Golden Horse-shoe Company, of Kalgoorlie, but owing to the comparatively low grade of the ore and its irregular occurrence, adverse economic conditions often cause stoppages. Last year F. R. Feldtmann, one of the members of the West Australian Geological Survey, made an examination of this district, and his preliminary report is issued in the Annual Progress Report of the Survey just published. We quote Mr. Feldtmann herewith.

Northampton township, the centre of the mining district, is situated 27 miles direct north of Geraldton, or 34 miles by rail. The new township of Galena is situated immediately south of Murchison River, about 31 miles (45 miles by road) north of Northampton and about 8½ miles (12 miles by road) N.N.E. of Ajana, the terminus of the railway from Geraldton.

The metalliferous district consists of an elevated tract of country, the present surface of which is strongly undulating, where the removal of the overlying Jurassic strata has exposed the crystalline rocks. The southern portion of this area of crystalline rocks, which consists largely of garnetiferous gneiss or gneissic granite, has been surveyed by W. D. Campbell, whose map, published in a Bulletin published in 1910, shows the southern end of the main belt to be about seven miles due east of Geraldton. The northern extension of this belt has not yet been determined, and in view of the economic importance of these rocks a broad survey of this portion of the gneissic belt is highly desirable. From hasty observations made on the road from Northampton to Galena, it appears probable that the gneissic rocks extend without a break to and beyond the Murchison River, with the possible exception of the high Binnu sand plain. How far they extend eastward along Murchison River has not been determined, but they are known to occur at the 10 Mile Pool. The length of the metalliferous belt, if continuous, is therefore at least 70 miles, the maximum width being probably about 15 miles. The belt, however, is very irregular and the average width is probably considerably less.

The gneiss is cut by a number of basic (greenstone) dykes, striking nearly north-north-east, and by a greater number of pegmatite dykes or veins, with, so far as could be determined, similar strike, as have also the lodes. The lodes are closely associated with these dykes, but their relationship to the basic dykes is purely structural, the lines of fracture along many of which these dykes made their way forming lines of weakness during subsequent periods of shearing. On the other hand, the formation of the ore-bodies appears to be closely connected with the introduction of the pegmatites, which probably extended over a considerable period, the earlier stages of which were marked by high temperatures, as shown by the wide development of garnet in the gneiss and also, though but sparsely, in some of the pegmatites and the formation of tourmaline in a few of the pegmatites and their ultra-acid varieties, such as certain of the quartz reefs. The formation of the ore-bodies took place during the final stages of igneous activity, under lower temperature conditions. The occurrence of lead, zinc, and copper deposits as the final products of granitic magmas is by no means uncommon in other countries. In prospecting for new lodes it is advisable to examine closely the immediate neighbourhood of the greenstone and pegmatite dykes.

The gneissic rocks are pale to fairly dark greyish rocks, usually fine in grain, which proved to be garnetiferous wherever examined. The ferromagnesian appears to be chiefly biotite, possibly chloritized in places. Pegmatitic facies of these rocks, with large felspars and garnets, occur. In some places the gneissic structure of the rocks is well marked, in others the rocks are compact and massive, the only traces of a gneissic structure being a slight parallelism of the composing minerals. Occasional zones of sheeted or laminated rock occur in the gneiss, marking lines of intense shearing and probably corresponding to the laminated jaspers so commonly associated with the goldfields greenstones and, in places, with the Pre-Cambrian sediments. The general strike of these sheeted zones is nearly north-west; they were apparently formed prior to the introduction of the basic dykes and the pegmatites.

The basic dykes are for the most part coarse to fine-grained massive epidiorites, from dolerites, but they probably range from intermediate-basic to ultra-basic in composition. Their most remarkable feature is the general uniformity of their strike, which round Northampton averages about N. 32° E.; they appear to be nearly vertical. They are of great length, and, on the average, of considerable width, several of those examined being 60 or 70 ft. wide in places, and Gregory mentions some as attaining a width of 180 ft. Being harder than the surrounding gneiss they usually form prominent outcrops, a rounded outline being characteristic of the weathered outcrops and boulders. Among those lodes, which for a part of their length at least occur along the margins of basic dykes, are the Wheal Ellen, Gwalia (south lode), Unaring, Derby Syndicate (Loc. 325), Wheal Beta, and Yandanooka at Northampton, and the Surprise at Galena.

The pegmatites are of great variety. The occurrence of pegmatitic veins apparently as a facies of the gneissic rocks has already been mentioned, but most of the pegmatites undoubtedly belong to the stages of igneous activity immediately preceding ore deposition, and are intrusive into the gneiss. No direct evidence was obtained as to the relative age of these rocks and the basic dykes, but from their composition and close relationship to the lodes they appear to be younger than the basic rocks. The pegmatite dykes are much more numerous and much smaller, as a rule, than the epidiorites, their width usually ranging from a few inches to a few feet, but it is probable that much larger dykes, particularly of the more acid varieties, occur. Their dip appears to be very similar to that of the lodes.

One of the commonest types of pegmatite is a coarse-grained rock, consisting chiefly of felspar and quartz, mainly in graphic intergrowths, with some large and small flakes of a silvery greenish-grey mineral, probably vermiculite; flakes of graphite are common in some specimens and are probably contemporaneous with the other minerals composing the rock. In some localities the felspars are white, in others, such as the Baddera and Victoria mines, they

[illegible] Aplitic forms of these rocks [illegible]. Specimens of pegmatite of this type from the Wheal Alpha mine contain malachite and azurite, deposited in thin films through the rock, as well as in one specimen, in a vughy veinlet, probably on the wall of the dyke. A variety from an outcrop on the Gwalia mine contains large felspar crystals in a ground-mass consisting largely of a graphic intergrowth of tourmaline and quartz. A different and much more acid aplitic type of pegmatite occurs in the Baddera and Wheal May mines. It is composed of greyish glassy quartz, containing numerous small pale salmon-pink felspars. Another highly acid type from the Baddera is a rock composed of glassy quartz with fairly numerous small garnets; a few minute specks of mica are also present. Extreme ultra-acid types are represented by some large quartz reefs, carrying very sparsely distributed groups of large tourmaline crystals.

The lodes occupy zones of intense shearing and brecciation in the gneissic granite. Where a shear zone is along the margin of a greenstone or pegmatite dyke, these rocks may also be sheared and brecciated. The strike of the lodes is roughly parallel to that of the greenstone dykes, but is, however, less regular. A few of the lodes, including the Uga, the Baddera branch lode, and parts of the Chiverton, Nooka, and Wheal Alpha lodes, strike approximately north. The Surprise lode, at Galena, strikes nearly north-north-west. The dip is usually north-west, at a steep angle, but in places the lodes are vertical, or even have a slight south-easterly dip. The Surprise lode dips west-south-west. In length the lodes range from about three chains (Derby Syndicate lode) to about one mile (Waneranooka lode), averaging, perhaps, between 30 and 40 chains. The width is very variable, and a distinction must be drawn between the width of the lode-channel or zone of shearing and brecciation, and that of the ore veins or shoots. The lode may contain no ore, even where the shear zone is of moderate width, and shearing and brecciation are fairly well marked, or payable ore may occupy the full width of the channel. The ore-bodies may range in width from a fraction of an inch to 30 ft., or even more. In the Surprise mine sheared rock, carrying veins of galena, occupies a width of more than 100 ft. at the 110 ft. level. In most of the lode-channels the shearing stresses have found relief along one or more planes in a main zone of intense shearing, with the formation of a narrow band of crushed clay (flucan) along the planes; the remainder of the rock in the main zone being brecciated. Shear planes, roughly parallel to the main planes, as well as irregular joint planes, were also formed in the rock for some distance outside the main shear zone.

That the ore-bearing solutions were introduced during a period of relief from pressure is indicated by the numerous vughs, the sugary, or crystalline and glassy character of the quartz, and the coarsely crystalline structure of the galena in the larger veins. In the main body of the lodes, where most affected by the ore-bearing solutions, the rock breccia has been recemented by silica, the cement now consisting of very finely crystalline quartz, coloured greyish by inclusions of partly digested rock, and in places containing minute specks of pyrite. As is usual in lode formations the boundaries of the ore-bodies are ill-defined, and the ore is not necessarily confined to the rock enclosed between two particular planes or [illegible] shear plane, which forms a convenient hanging wall at one point in a mine, may be used as a foot-wall at another point. It is probable that shearing also took place along the lode-channels subsequently to ore-deposition. In addition to the varied directions of the striæ on the shear planes, which in the Wheal Ellen mine are in places vertical, in places horizontal, thus suggesting local movement, the main shear planes are in many places marked by a few inches of crush clay, and by a band of crushed rock and clayey material, which carry no ore even where the lode is rich; moreover, bands of barren schist and occasional joint or shear planes occur in the body of the lode. It is difficult to explain why these should contain no ore, except on the assumption that they are subsequent to ore deposition.

So far as could be judged all the lodes of this district are similar in structure, and, with the exception of the Surprise lode, where barite veins are a conspicuous feature in the ore-shoot, in their gangue, though differing in their degree of silicification. Any classification is therefore necessarily arbitrary. It is, however, convenient to group them according to the proportions of economic minerals present into:—

(*a*) Galena lodes carrying only negligible quantities of blende, copper ores, and pyrites; the Baddera, Surprise, and Wheal May lodes being of [illegible].

(*b*) Galena blende lodes, carrying galena and blende in nearly equal proportions with minor quantities of copper ores (chiefly chalcopyrite), pyrite, and marcasite; the Wheal Ellen belonging to this group.

(*c*) Copper lodes, in which galena and blende, if present, occur only in small quantities; in this group, however, pyrite and marcasite are probably present in fair quantities; the Wheal Margaret and Victoria may be taken as representative of this group.

As stated, this classification is purely arbitrary, the three groups grading into each other through intermediate types. Detailed observations had, unfortunately, to be confined to lodes of the first two groups, as none of the workings on the Northampton copper lodes were accessible and practically all the ore had been removed from the dumps.

In the lodes of the first group the galena occurs usually as veins of coarsely crystalline material along the main shear planes; as coarse octahedral or cubo-octahedral crystals lining vughs and in places associated with glassy or sugary quartz; as veinlets of more finely crystalline material in the body of the lode; or, more rarely, in a fine-grained massive, in places schistose, form, probably a replacement of the rock along narrow zones of intense shearing. In the rich shoot in the Surprise mine groups of coarse galena crystals separated by tiny irregular veinlets of quartz occur over a width of 20 ft. in places. The blende and pyrite usually occur as narrow veins or veinlets filling shear or joint planes outside the main body or in the poorer portions of the lode.

In those of the second group the galena occurs as before, but blende is also found in fairly large masses in the body of the lode as well as occurring as in the first group. Pyrite occurs as in the first group, but marcasite is in places associated with galena in the body of the lode. In addition, finely disseminated chalcopyrite (altering to malachite in the oxidized zone) is fairly common in the more quartzose portions of the lode.

The secondary deposition of galena or blende on

a large scale appears to be very doubtful, no deposits definitely formed in this way being known. As is suggested by their mode of occurrence, rich shoots such as those of the Surprise, Geraldine, and Baddera mines are most likely due to the primary deposition of galena from ascending solutions under favourable conditions. On the other hand, the secondary deposition of copper sulphides on a large scale near water-level is of common occurrence. Whether this has taken place to any great extent in the Northampton lodes it is, in the absence of accessible workings, impossible to say. That a certain amount of secondary deposition has taken place is, however, suggested by the presence of such minerals as covellite and chalcocite, though even these minerals may be of primary origin.

There is every probability of the lodes extending to very considerable depths below the limits of the present workings, and there is no evidence to show that rich shoots may not occur below those hitherto discovered. At greater depths, however, the lead ore may change in character, becoming more compact and finer-grained and containing larger proportions of pyrite and chalcopyrite, and probably, also, of blende in lodes like the Surprise and Baddera. In spite of the number of years since mining first started, the district has not been thoroughly prospected, and the recent discovery of the Surprise lode shows that by careful prospecting other rich lodes may yet be found.

IRON ORES OF NORMANDY

At the meeting of the Iron and Steel Institute held last month at Paris, P. Nicou gave an outline of the present position of France's iron ore resources. The restoration of Lorraine to France, and the elimination of German control from the ore-fields of Normandy, Brittany, Maine, and Anjou, the old provinces constituting north-western France, have put her once more in a strong position metallurgically, and the owners of the deposits are seeking customers in Great Britain. The Lorraine deposits have been described many times, but those in north-western France are not so well known.

We quote from Monsieur Nicou's paper herewith with regard to the Normandy deposits, those in Anjou, Maine, and Brittany not being of as great importance at present.

The iron ores of Normandy, Anjou, Maine, and Brittany are, from many points of view, and particularly from their geographical situation, the most suitable of all the French deposits for British ironworks. All the mines now, or in the future, to be worked are in close proximity to the sea. Those of Segré, in the Anjou ore-field, the farthest from ports of embarkation, are only 85 and 135 kilometres distant by rail from Nantes and St. Nazaire respectively, while the Ferrière and Halouze mines, the farthest south of the Normandy mines actually in operation, are within 75 and 80 kilometres of Caen. Before the war a large number of important German companies had acquired considerable interests in these mines, and a heavy trade with Westphalia had commenced, which militated against all attempts to foster an ore trade with Great Britain. At Caen, more especially, the exports to Germany, which in 1908 amounted to 131,193 tons, had risen by 1913 to 342,281, whereas for these two years the exports to Great Britain had only risen from 81,999 to 144,409 tons.

The Normandy deposits spread over the three Departments of Calvados, La Manche, and l'Orne. Though the second largest deposits in France, they contribute only a small proportion of the total output. In 1920 the proportion of output had fallen to 3·55%. This decrease is due to the reopening of the French mines in recovered Lorraine; and the decrease is even less than might have been expected, owing to the destruction of numerous works and mines in the east of France. Whatever the statistics may portend, the production of ore from the Normandy mines had appreciably increased during the years which immediately preceded the war, and the 1913 output would have justified the hope that in 1914 extraction would have reached a million tons. Great developments were in progress at the Soumont mines, and particularly at St. André and at Barberry, and but for the war the Normandy deposits might well have amounted to several millions of tons annually. A considerable proportion of this output would have been employed at works in the north of France; Halouze and La Ferrière are mines belonging to the Aciéries de France et de Denain-Anzin, and the Isbergues and Denain works of the company would have taken the largest proportion of their output. The Forges et Aciéries du Nord et de l'Est had large interests in the Larchamp mine, and would have mixed the ores from this mine with those from their Pienne concession in Meurthe-et-Moselle, thus securing a particularly satisfactory charge for their blast-furnaces. These three mines, Halouze, La Ferrière, and Larchamp, all situated on the main syncline of Ferrière, had in 1913 produced 373,000 tons of ore, that is, 45% of the whole Normandy production. New works in Pont-à-Vendin and at Dunkerque were similarly to have derived a large proportion of their ore requirements from Normandy. In addition to the foregoing, blast-furnaces in the course of construction in Calvados, in the immediate neighbourhood of Caen, to be provided with steel works and rolling mills, were to draw their supplies from the Soumont mines, and having associated interests in Westphalian works were to exchange ore for coke with the latter, thus accomplishing a purpose towards which British ironmasters ought now to address themselves. Other concessions in which Germans held the great bulk of the shares, or in which, through the intervention of Dutch shareholders, they possessed large interests, were equipped with plant destined to increase their productive capacity and develop an extensive trade with their shareholder customers.

Since the war the situation has greatly changed. The northern works, such as Denain, Isbergues, Valenciennes, and Pont-à-Vendin, have been completely destroyed by the Germans, or so vitally injured that it will take many years to restore them. This is one of the reasons for the notable decrease in the iron-ore production of Normandy. The Caen works, taken over by a company which has eliminated the German element, cannot develop to the extent wished for. Hence the Normandy mines must look for their development to the

[illegible] while [illegible] them [illegible]

The [illegible] either as [illegible] carbonate or hematite. Both may exist simultaneously, as the hematite always passes into carbonate at a greater or less depth. Normandy hematites are at present chiefly mined at St. Rémy, St. André, and May. The St. Rémy ores are the richest of all the Normandy ores, and contain 50 to 55% of iron, 10 to 12% of silica, 3% of alumina, 2·5% of lime and magnesia, 0·6 to 0·7% of phosphorus, and 3% of water. At St. André and May the iron percentage is lower, being between 46 and 51, with 14 to 16% of silica. The other concessions contain chiefly or entirely carbonate ores which have to be calcined. Only 12 to 15 kg. of fuel per ton of ore is required for calcining them, and the yield varies from 75 to 79%. On their withdrawal from the kilns the ores from the three following mines contain: Halouze, iron 48 to 49%, silica 14 to 16%; La Ferrière, iron 47 to 49%, silica 13 to 15%; Larchamp, iron 48 to 49%, silica 14 to 15%. The proportion of alumina varies from 4 to 7% and the lime and magnesia from 3·5 to 4·5. The phosphorus remains between 0·6 and 0·7%. These calcined carbonates are therefore relatively rich, and the three mines in question are just those from which export would be the easier. Soumont ores only yield 45·9% of iron after calcining, the silica being higher than in the ores just described. The ores of Mortain, Bourberouge, and Jurques are very similar to those of Soumont. It will be seen that while the ores are somewhat siliceous, they are, generally speaking, high in iron. Their composition shows that they are suitable not only for making basic pig iron, but also for mixing, while without any fluxes they can make phosphoric foundry pig containing 1·2 to 1·3% of phosphorus, as well as pig iron suitable for open-hearth furnace working. The carbonates are usually porous when calcined, as is shown by their weight per cubic metre. This varies, after calcination, from 1,600 to 1,650 kg., and thus presents a distinct advantage when they are smelted.

Four principal regions may be distinguished, each corresponding with a particular syncline: May, Urville, Falaise, and La Ferrière. The most northerly comprises the concessions of May, St. André, Bully, and Maltot, which were granted before the war. Only two of these are being worked. At May the beds have a dip of 45° and a thickness varying from 4 to 6 metres, but of which only a thickness of 2·5 metres is being actually worked, the remainder being too high in silica. The sinkings carried out by the Société des Mines et Produits Chimiques reach a depth of over 100 metres below the surface and extend underground for over 4 kilometres. A large shaft at Lorguichon, near to the mineral railway connecting the Soumont mine with Caen, has been sunk to a depth of 150 metres and will allow of an annual production of 150,000 tons of ore. This ore is a hematite containing 46 to 47% of iron. In 1920 production had reached 100,189 tons, and fell, owing to the war, to 45,256 tons in 1919. In 1919 it had increased to 62,051 tons. At St. André an almost vertical bed is worked to a depth of nearly 100 metres, and the ore is got from a bed of hematite 2·5 metres thick, overlain by a bed of carbonate not yet being worked. The outputs in 1913, 1919, and 1920 respectively were 89,225, 60,956, and 75,567 tons. The Bully and Maltot concessions have hitherto only been explored by bore-holes. It is along the May syncline that investigations eastward have been pursued to ascertain whether the workable beds of May and St. André extend. The results have been of sufficient interest to warrant the Government granting, this year, a series of concessions extending as far as the railway from Argentan to Mezidon. These concessions at Condesur-Ifs, Fieville, Garcelles, d'Ouézy, d'Ouville, and St. Pierre-sur-Dives cover a greater area than all the others in Calvados put together.

The second syncline, sometimes known as La Brèche du Diable, but more commonly as Urville, comprises six older concessions, Soumont, Perrières, Barberry, Estrées, Gouvix, and Urville. Investigations made in this instance, westward, have led to the prolongation of the syncline being established as far as its outcrop, and have led, since the commencement of the year, to the granting of the Cinglais concession. Of all the concessions of this second basin the most important in every respect is that of Soumont, which supplies the Caen blast furnaces of the Société Normande de Métallurgie, with which they are linked up by a private railway. Here there occurs a seam of carbonate ore having a dip of 30°, which appears from bore-holes sunk to depths of 400 metres, to get less steep as it becomes deeper. So far the seam has been proved for a depth of 200 metres by slopes and roads which have established its continuity and constancy. The ore gives, on calcination, 45·9% of iron, and roads have been driven for several kilometres. Down to depths of 60 metres hematite is found, but below these depths it disappears completely. In 1913 the mine produced 71,637 tons of ore, of which 9,000 tons was imported into Germany and the rest put into stock. Since that date the work done by the new company owning the Caen furnaces (Société Normande de Métallurgie) has been directed to supplying adequate quantities of ore for the consumption of the blast-furnaces, and to making calcining tests, which have yielded excellent results. In 1919 the output of carbonate ore amounted to 40,400 tons, of which 24,042 went into stock and 16,358 was passed through the kilns. By December the stocks had risen to 219,602 tons of raw ore, and 52,223 tons of calcined ore. These stocks were heavily drawn upon during 1920 for consumption at the works. During 1920 Soumont produced 4,339 tons of hematite and 65,322 tons of calcined carbonate. The Barberry concession, in which the German Gutehoffnungshütte held the interest, was naturally sequestrated during the war, and has since been completely idle. In 1913 the production was 16,624 tons of calcined ore from a bed in which only a thickness of 2·5 to 3 metres was worked, to avoid getting a too siliceous ore. Arrangements had been made for the rapid development of this mine, for an output of 300,000 tons, which shows the importance attached by German metallurgists to the Normandy deposits. Soumont, which was also to supply part of the ore needed at the Thyssen works in Westphalia, was in 1914 being prepared for an output of 500,000 to 600,000 tons annually, beginning with 1915. The war stopped this development, but the plant is capable, whenever required, of realizing such outputs. Of the other concessions on this syncline, only the Gouvix mine has been restarted by the Société des Forges et

Aciéries de Firminy, for the purpose of getting ready to supply the Dunes works near Dunkerque. The ore is a carbonate, and calcining kilns have been installed. Extraction has only been of a preparatory nature, and the tonnage has hence been small.

The third Normandy syncline, that of Falaise, is the best known, as it contains the St. Rémy concession, the oldest (having been granted in September, 1875) and the richest. A bed of hematite 2·5 metres, of very uniform quality, overlain by a thickness of about 1 metre of carbonate ore, is worked. The carbonate ore has a purplish colour, and was not formerly worked, although for a few years it has been exploited. The hematite contains 51 to 55% of iron and the raw carbonate 41 to 42%, with 12·9% of silica. The bed is only worked to slight depths—33 metres on an average—below the surface. Production, which in 1911 reached 106,852 tons, fell in 1913, as the result of a long strike, to 77,620 tons. In the year 1920 the output was 78,713 tons, of which 43,218 tons were the richest. The first-named produces only carbonate. Throughout 1919 it was only working part time, and whereas in 1913 its output was 89,896 tons of calcined ore, in 1920 it only produced 18,275 tons of ore, of which 14,588 tons were calcined. The seam has a thickness of 5 to 8 metres, with numerous changes of dip and strike, creating difficulties in working. One shaft is at work, and the ores are transported by an aerial ropeway to the station at Chatelier, 7 kilometres away, on the line from Domfront to Flers. Twelve calcining kilns, with forced draught, have been installed at the mines. The Halouze concession, along the immediate prolongation of the latter, has a somewhat narrower seam, 5 to 7½ metres in thickness. It is worked by two shafts, each 180 metres deep, and by an incline. Actual working is confined to depths not exceeding 130 metres, but provision has been made for extraction at greater depths. There are eight calcining kilns, and a railway 8 kilometres in length connecting the mine with the station at

North-Western France, showing Position of Iron Ore Deposits.

hematite and 35,595 tons were carbonate. The remaining concessions on this syncline, at Ondefontaine, Jurques, and Montpinçon, produce only carbonate of much poorer quality, and with the exception of Jurques, which has been worked by the Société Français des Mines de Fer, have been little developed. At Jurques there appear to be three beds, two of which are workable, but of which only one is at present being worked. It has a thickness of 1·80 metres, and a dip of 55°. The investigations quite recently made at Montpinçon have led to the recognition of only one seam, much faulted and probably unworkable. The description of these three synclines completes the account of the Normandy deposits occurring in the Department of Calvados.

The fourth syncline spreads over the Departments of l'Orne and La Manche, and covers two widely differing regions; the eastern in l'Orne, with the Mont-en-Gérome, La Ferrière, Halouze, and Larchamp concessions, and the western, containing the Mortain and Bourberouge concessions, Larchamp, Halouze, and La Ferrière are at the present time the three most important mines in Normandy, and, with the exception of St. Rémy, Chatelier. The output in 1913 was 152,656 tons of ore. In 1920 only 44,559 tons were produced, of which 40,678 tons were calcined and dispatched. In some places the concession yields a hematite ore, but in small amounts only as compared with the carbonate ore. The mine belongs to the Compagnie des Aciéries de France. At La Ferrière, which belongs to the Denain Anzin Company, the seam is the prolongation of that encountered at Larchamp and Halouze, and has a dip of between 35° and 40° south, which becomes steeper northward before reaching Halouze. Eight kilns are installed for calcining the carbonate ore, and the mine is connected by rail with the St. Bomer station on the Flers-Domfront line. Most of the ore was, before the war, used at the works of the proprietors, but these having been destroyed by the Germans the output has been greatly reduced, and only the requirements of outside customers have been catered for. While, in 1913, 121,650 tons of calcined ore were dispatched from the works, the 1920 output was only 32,500, while the kilns calcined 50,100 tons, the difference being taken out of stock.

Of the other concessions on the La Ferrière syncline, the Mont-en-Gérome mine is not as yet

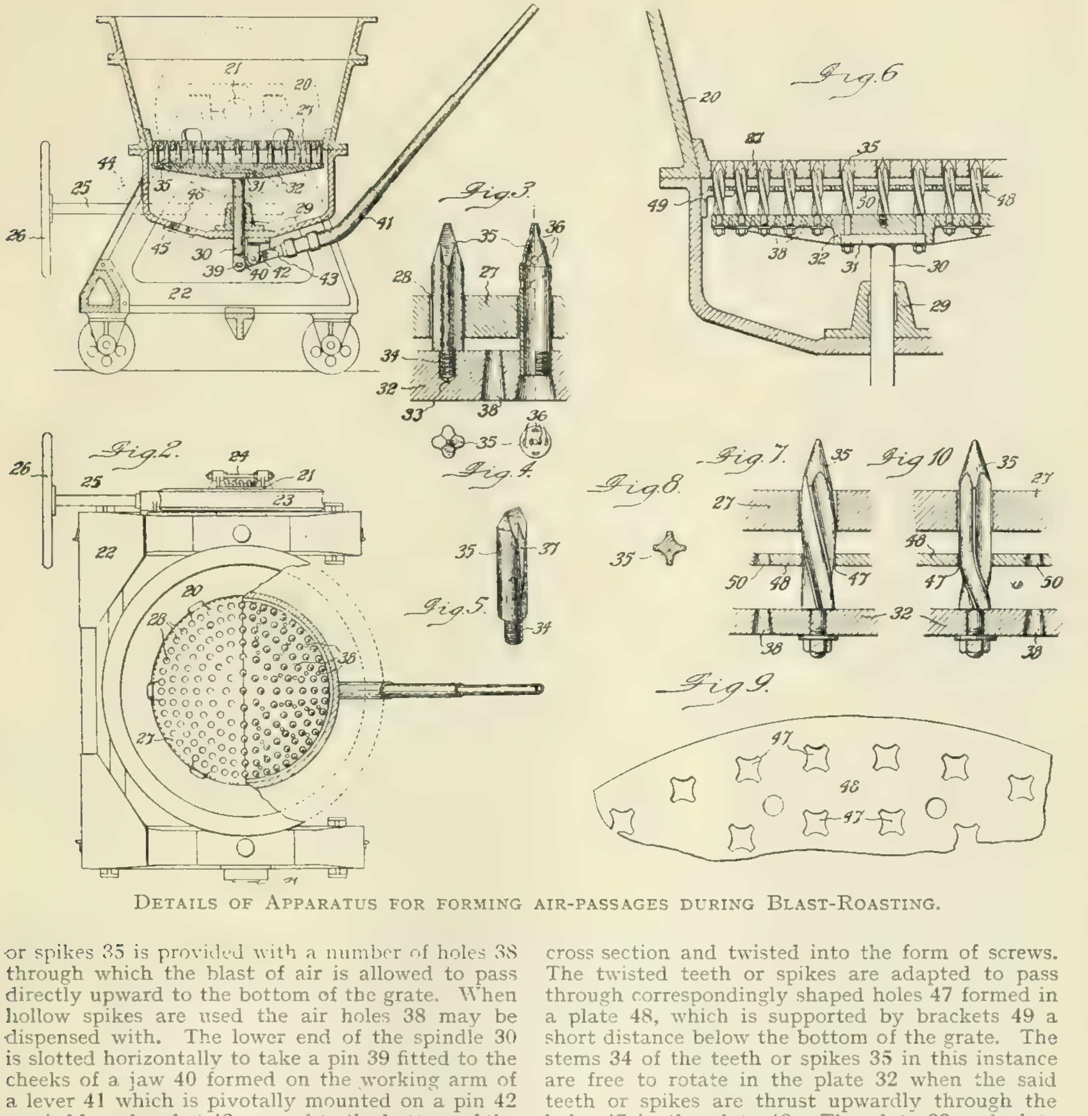
been worked, only trial borings to ascertain the extent of the seam, its thickness and quality, having been carried out. According to the information yielded by these bores, the seam is less important than those just described. At Bourberouge there is a workable seam of 2·5 metres thick, with an average dip of 30°, and at Mortain the thickness reaches 6·5 metres, and the maximum dip is 54°, which becomes steeper as the depth increases. Both these mines, which belong to the Société Française des Mines de Fer, were before the war worked for the export trade. They are connected by rail respectively with the Avranches station on the Domfront line, and Mortain on the Vire line. Kilns were installed, but by 1913 production had only just begun and the output was 34,553 tons of calcined ore at Bourberouge, and 6,833 tons at Mortain. The former mine became flooded during the war up to its adit level; at Mortain the same thing occurred to the lower levels.

Blast-roasting. — British Patent 13,958 of 1920 (146,936), issued to the Mining and Metallurgical Processes Proprietary, Ltd., of Melbourne, as assignees of Gilbert Rigg, of the Broken Hill Associated Smelters, describes an improved apparatus employed in blast-roasting. Mr. Rigg's work in this line is well known, for articles have been published in the MAGAZINE for June, 1918, and February, 1920, and he read a paper before the Institution of Mining and Metallurgy in May, 1920. We quote this patent specification in detail.

The invention refers more especially to means for perforating and thus opening up or breaking the clinker which normally forms immediately over the grates in such operations. In metallurgical operations involving the passage of a blast or current of air through a body or charge of ore upon a grate, it has been found that the layer of material immediately over the grate is usually fused into a more or less impervious cake or clinker and that consequently the passage of air is seriously impeded and frequently rendered irregular and uneven, involving constant attention in the filling up of blow-holes to avoid intense local action. In many cases this results in the limiting of the thickness of the charge to a comparatively thin layer and retards the completion of the operation. It has been found by an examination of the treated charge that the lower layer has fused into a compact mass of clinker, although the upper portions of the charge are not so affected. The object of the present invention is to provide means whereby the layer of clinker or slag formed over the grate is periodically perforated and thereby broken or opened up for the passage of the air blast. This object is accomplished by providing mechanical means by which the layer of clinker or slag is intermittently perforated. These mechanical means preferably comprise a number or series of projecting teeth or spikes adapted to be intermittently forced through the layer of clinker or slag as the same is formed over the grate, thereby perforating and opening it up for the passage of the air current. These projecting teeth or spikes are preferably adapted to work in conjunction with the grate, and in practice the same teeth or spikes are caused to project through the perforations or interstices of the grate, being mounted upon a suitable carrier or member which is adapted to be moved up and down by suitable mechanical means.

An apparatus embodying the features described is illustrated in the accompanying sheets of explanatory drawings. Fig. 1 is a view in sectional side elevation of a pot, as used in the Huntington-Heberlein process, fitted with mechanical devices for perforating the clinker formed over the grate therein. Fig. 2 is a view in plan of Fig. 1, part of the pot being broken away to show details in the mechanical means devised for perforating the clinker. Fig. 3 is a view illustrating two forms of spikes or teeth for use with the apparatus. Fig. 4 is a view in plan of the spikes or teeth shown in Fig. 3. Fig. 5 is a view in perspective of another form of spike or tooth. Fig. 6 is a view in sectional elevation of part of a pot showing a modification in the means employed for perforating the clinker. Fig. 7 is a view in sectional elevation of part of Fig. 6, and shows a modified form of tooth or spike. Fig. 8 is a view in sectional plan of the tooth shown in Fig. 7. Fig. 9 is a view of part of a constructional detail shown in Fig. 6. Fig. 10 is a view similar to Fig. 7, showing another modified form of tooth or spike.

In these drawings the reference numeral 20 designates a pot having trunnions 21 supported on a frame 22 provided with transport wheels of approved form. One of the trunnions 21 is fitted with a worm wheel 23, which gears with a worm 24 carried by a shaft 25 fitted with a hand-wheel 26, which is adapted to be operated to tilt the pot sufficiently to empty some of its contents as desired. A grate 27 is supported at an approved point in the height of the pot, and this grate preferably comprises a cast metal plate having a series of holes 28 formed vertically therein. The grate 27 is preferably mounted removably within the pot to permit of its being replaced by another when worn out or damaged. The bottom of the pot is provided with a centrally disposed hole above which is mounted a guide member 29 for a spindle 30, which is adapted to be reciprocated vertically therein. The upper end of the spindle 30 is formed with a cap or flange 31 which is bolted to the centre of a plate 32 which conforms to the shape, and is somewhat smaller than the interior of the lower part of the pot. The plate 32 is formed with a series the threaded holes 33 which are adapted to take the screwed shanks or stems 34 on the lower ends of a series of teeth or spikes 35. The teeth or spikes are preferably pointed or sharpened on their upper ends and normally project upward into the bottom of the holes 28 in the grate 27. The teeth or spikes 35 may be made to the same shape as, but slightly smaller in cross section than the holes in the grate, or they may be made of such other cross-sectional shape as will permit of the passage of air through the holes when the teeth or spikes are thrust upwardly through. The teeth or spikes may be given a cruciform shape in cross section, as shown in Fig. 4 of the drawing, or they can be made hollow as represented partly in sectional elevation in the right-hand side of the same figure. When the teeth or spikes are made hollow as shown, the plate 32 is bored right through to permit of the air, forced under pressure into the bottom of the pot, passing freely upward to and through the holes 36 formed in the upper end of the said hollow teeth or spikes. The upper ends of the teeth or spikes can be provided with chisel points, and when made of round bar material their sides may be formed with grooves or flutings 37 (see Fig. 5 of the drawings). In order to permit of the uniform distribution of the blast beneath the grate 27 the plate 32 carrying the teeth



Details of Apparatus for forming air-passages during Blast-Roasting.

or spikes 35 is provided with a number of holes 38 through which the blast of air is allowed to pass directly upward to the bottom of the grate. When hollow spikes are used the air holes 38 may be dispensed with. The lower end of the spindle 30 is slotted horizontally to take a pin 39 fitted to the cheeks of a jaw 40 formed on the working arm of a lever 41 which is pivotally mounted on a pin 42 carried by a bracket 43 secured to the bottom of the pot. The power arm of the lever 41 preferably is made up of two or more telescopically connected parts to permit of it being shortened when the pot is to be tilted to empty it of its contents. The connexions between the parts of the power arm of the lever 41 can be made in any well-known manner. The air blast is supplied to the lower part of the pot through a pipe 44 as shown in dotted lines in Fig. 1 or in any other approved way. The lower part of the pot can be cleaned as and when desired by removing the cover 45 on an opening 46 in the bottom thereof.

If preferred the teeth or spikes 35 can be made as shown in Figs. 6 and 7, and means may be provided for effecting a partial rotation of the teeth or spikes when they are being thrust upwardly through the holes in the grate 27. In this last-mentioned form of apparatus the teeth or spikes are made of cruciform or other irregular shape in cross section and twisted into the form of screws. The twisted teeth or spikes are adapted to pass through correspondingly shaped holes 47 formed in a plate 48, which is supported by brackets 49 a short distance below the bottom of the grate. The stems 34 of the teeth or spikes 35 in this instance are free to rotate in the plate 32 when the said teeth or spikes are thrust upwardly through the holes 47 in the plate 48. The plate 32 and plate 48 are provided with holes 38 and 50 respectively to permit of the free passage of the air blast to the grate.

When the lower parts only of the teeth or spikes are twisted as shown in Fig. 10 of the drawings, the teeth or spikes will be partially rotated when their screwed or twisted parts are passing through the holes 47 in the plate 48.

After the charge in the pot has been ignited and the blast turned on, the formation of dense clinker or partially slagged material commences to take place. By means of the lifting mechanism the teeth are forced upwards into this dense layer, which they perforate, thus allowing the blast to pass through. It will be seen that as these teeth are uniformly distributed over the lower surface of the charge, a uniform distribution of air through the charge is effected. The operation of raising the teeth and perforating and opening up the bottom clinker

[illegible] thus [illegible] and a more uniform [illegible] obtainable in the case of blast- [illegible] the treatment of ores for the formation of oxides and the like by the operation of a blast or current of air through a mixture of the ore and fuel it is possible to work with much deeper charges than have hitherto been found practicable.

The addition of atomized water to the air blast can be conveniently made use of in regulating the temperature of the roasting mass. This application is made possible by the uniformity of the blast distribution. Where blast distribution is irregular and patchy the cooling effect of the atomized water would be localized, and give rise to irregular roasting.

Anodes for Copper Deposition.—British Patent 13,572 of 1920 (157,871) contains an interesting discussion of the problems at Chuquicamata as regards the life of the anodes in the electro-deposition of copper. These problems have been referred to on several occasions in the MAGAZINE, and they have constituted the chief subject of study at this copper mine. The patent is granted to the Chile Exploration Company, of New York, as assignees of Colin G. Fink. We quote herewith from the specification.

For efficient and satisfactory use in the electrolytic recovery of copper from copper sulphate electrolytes, an anode should possess certain properties. In the first place it should be of the so-called insoluble anode type, that is to say, it should be to a high degree insoluble in the electrolyte, or in other words, it should possess high resistance to anodic disintegration. In addition the anode should have high electrical conductivity, and a low anodic potential in order to keep the electrical losses as low as practicable. Again, the anode should be of such a character as to permit the ready discharge of oxygen gas therefrom, thereby eliminating or minimizing the undesirable consequences of polarization. In practice it is generally only possible to approximate the ideal condition with respect to each of the aforementioned properties, and accordingly it is necessary in the production of an anode for commercial practice to resort to a compromise of the ideal conditions with respect to these properties in order to obtain an anode possessing the desired properties to a more or less satisfactory degree.

The present invention contemplates the provision of an improved anode possessing in a remarkably satisfactory degree the aforementioned desirable properties, made up of an alloy containing cobalt and silicon. A depolarizing ingredient, such as manganese, is preferably included in the alloy, and, as a result of electrolytic action, provides a depolarizing coating or film for the surface of the electrolode which facilitates the discharge of oxygen gas therefrom. A hardening agent is also preferably included in the alloy, and serves the purpose of hardening the surface coating or film of the depolarizing agent. Chromium may be advantageously used as the hardening agent, and tungsten, molybdenum, and uranium may also be used as the hardening agent.

The improved electrode of the invention is accordingly made up of an alloy of which the principal constituents are cobalt and silicon. In its preferred form the electrode also contains manganese and chromium, together with a certain amount of carbon. Excellent results are obtained with an alloy of the following composition: 11·5 to 13%, silicon, 4 to 6%, manganese, 4 to 6%, chromium, 0·8 to 1·2%, carbon, and the balance cobalt. If desired, 5 to 30 parts of the cobalt content of the alloy may be replaced by manganese, or 5 to 12 parts of the cobalt content may be replaced by chromium, or 5 to 8 parts of the cobalt content may be replaced by nickel, without objectionably altering the advantageous properties of the alloy as an anode material. The proportion of carbon, manganese, chromium, and silicon can be somewhat varied, but in general neither the carbon, manganese, chromium, or silicon should be too low, or the corrosion of the anode will be objectionably increased. On the other hand, the carbon, manganese, chromium, and silicon content should not be too high. A high silicon content results in a decrease in the strength of the anode, and an increase in both its tendency to corrode and in its specific electrical resistance. If the carbon content is too high, the carbon separates out in a graphitic form. The best results are obtained with a carbon content slightly in excess of the amount which can be combined, so that there is a small amount of fine graphitic carbon, such as will give a grey surface to the fracture, but without any excess of graphitic carbon.

The alloys of cobalt and silicon are distinguished from alloys of other more or less similar metals with silicon in their availability for use as electrodes. This distinction, and the advantages of the cobalt-silicon alloys, are due in part to the anodic properties of the cobalt, that is, to its tendency to be deposited on the anode, which distinguishes cobalt from most other metals which deposit on the cathode. The advantageous properties of the cobalt alloys are further due to the peculiar characteristics of the cobalt-silicon alloys. Photo-micrographs of cobalt-silicon alloys containing about 12 to 15 % of silicon indicate that the silicon is in part present as such or in solid solution in the cobalt, while a large part is present in the form of a eutectic made up of a solid solution of cobalt silicide (Co_2Si) in the cobalt and perhaps also of the cobalt silicide itself. The photo-micrographs indicate that the resistance to corrosion may be largely due to the presence of the silicon and of the cobalt silicide.

With anodes of cobalt-silicon alloys and copper cathodes there is a voltage in dilute sulphuric acid of about 1·7 to 2·0 volts at a current density of 20 amperes per square foot of anode surface, and a spacing of 1½ in. between anode and cathode. Also there is a maximum strength against flexure to be obtained with a silicon content of about 12 to 15%. For example, a flexure strength of around 6,200 lb. per sq. in. (unit beam 1 in. square, 12 in. span) has been possessed by electrodes of this silicon content. Both any material increase and any material decrease in the silicon content of the alloy seems to decrease the mechanical strength of the electrode, and in general the greatest strength is obtained at between 12 and 15% of silicon. In its breaking strength the improved electrodes of the invention are to be distinguished from electrodes of iron and silicon, where, for example, a similar content of silicon gives an electrode with a flexure strength of about 1,000 to 1,500 lb. per sq. in. The greater strength of the cobalt-silicon electrodes of the invention, as compared, for example, with iron silicon electrodes, enables a much thinner

anode to be employed without objectionable reduction in strength, so that less space is occupied thereby in the electrolytic tanks or cells. Any considerable increase in the silicon content of the cobalt-silicon electrodes, as above noted, tends to increase both the voltage and the brittleness.

Good results are obtained with a carbon content of about 1%, or between 0·5% and 1·2%, and with a silicon content of from 12 to 15%. Graphitic carbon, as pointed out, is objectionable beyond a certain small amount, but inasmuch as cobalt will combine more readily than iron with a small amount of carbon, it is possible to include such a larger amount without an objectionable amount of graphitic carbon being present.

From investigations made of photo-micrographs of electrodes embodying the principles herein disclosed, it is believed that the improved electrode of the invention owes its advantageous properties to the fact that it is composed for the major part of two constituents. The first of these constituents is more or less soluble in the copper sulphate electrolyte, but possesses good electrical conductivity. The second constituent is relatively insoluble in the electrolyte, but is not a good conductor of electricity. The first constituent appears to be an alloy or a mixture of alloys of the various metallic constituents of the electrode, while the second constituent appears to be a eutectic, probably silicide of cobalt. It furthermore appears from the photo-micrographs that the structure of the anode is made up of particles of the first constituent, which particles are more or less enclosed or enveloped with a coating of the second constituent. The eutectic, accordingly, appears to provide a coating for the alloy particles, which effectively serves to prevent these particles from going into solution at an objectionably high rate, but at the same time this eutectic coating is so shallow or narrow as not to objectionably decrease the electrical conductivity of the electrode as a whole.

The cobalt-silicon anode is of special advantage in sulphate electrolytes containing appreciable amounts of nitrates and chlorides. In such electrolytes lead anodes disintegrate rapidly. Lead anodes stand up more or less satisfactorily in sulphate electrolytes free of nitrates or chlorides, but even in such electrolytes the cobalt-silicon anode of the invention is superior to lead anodes, since the anode of the invention possesses a higher current efficiency than a lead anode and stands up better in all electrolytes including those for which lead is adapted.

The electrode of the invention is of particular value when employed as an anode in the electrodeposition of copper from such solutions as are obtained upon leaching Chuquicamata copper ores. This electrolyte contains primarily copper sulphate, sulphuric acid, and a number of other salts, among which are included alkali nitrates, sulphates, chlorides, and iron sulphates. In addition, the electrolyte may contain small quantities of aluminium, calcium, magnesium, and potassium sulphates.

With an anode of the preferred composition hereinbefore mentioned, it is found that the loss in electrolytes of this character at 20° C. and at 20 amperes per square foot of anode surface, is approximately 0·5 lb. per one hundred pounds of copper deposited, and that the voltage from anode to cathode at this temperature is about 1·9 volts. It is found that higher temperatures give lower corrosion losses, which is in contradistinction to the behaviour of ferro-silicon anodes.

The manganese included in the improved electrode serves the purpose of a depolarizer. In an acid sulphate electrolyte at a temperature of from 10 to 15° C., the manganese goes into solution as permanganic acid. At temperatures of from about 30° C. to 60° C., this permanganic acid formation is practically absent, and instead there is obtained a heavy deposit of manganic oxide on the surface of the anode. In both cases, however, manganese dioxide is precipitated or deposited on the anode, but in the case of the warm or heated solution, the deposit of manganese dioxide is more adherent and there is practically no loss of manganese in the solution. This deposit of manganese dioxide, together with some cobalt oxide, on the anode acts as a depolarizer, and ensures the free discharge or liberation of oxygen gas from the surface of the anode. Moreover, cobalt-silicon anodes made up in accordance with the invention, but without manganese, have a tendency to corrode at the solution surface line, and this tendency is minimized by the addition of manganese to the alloy.

The addition of chromium or other chromium-group metal to the electrode acts to harden the manganese oxide film or deposit on the anode. Thus, the manganese dioxide film is more resistent to abrasion in the case of cobalt-silicon-manganese anodes containing chromium than it is in the case of anodes of similar composition but without chromium, tungsten, molybdenum, or uranium.

It will, therefore, be evident that while certain advantages of the invention are obtained without the inclusion of either manganese or a chromium-group metal in the electrode the presence of both of these materials is desirable, since the addition of these materials imparts to the anode further desirable properties. Thus it is found that the addition of chromium to the anode greatly facilitates duplication of low-loss, low-voltage anodes.

In the production of these anodes cobalt, with its normal impurities, may be employed, including some small percentage of nickel, iron, manganese, and carbon. Good results have been obtained with cobalt containing around 4 to 7% of nickel and iron together. In the production of the anodes the procedure is to melt the cobalt and add charcoal to increase its carbon content, or to simultaneously reduce a mixed oxide of cobalt, manganese, and chromium (or other chromium-group metal). The silicon is then added, together with the manganese to the molten cobalt, but it is found that the addition of the silicon to the cobalt results in a violent evolution of heat, so that care should be taken to avoid the addition of such large amounts of silicon as will result in objectionable overheating. The silicon can be added gradually or as carbide of silicon, or it may be combined with a small amount of cobalt and the resulting alloy or mixture added to the remaining portion of the cobalt. The violent evolution of heat which takes place when the silicon is added to cobalt is a further characteristic of the cobalt-silicon composition which distinguishes it from iron-silicon compositions.

The electrode of the present invention, in addition to its improved property of resisting anodic disintegration or corrosion, possesses in dilute sulphuric acid a relatively low anodic potential. In other words the voltage between the anode and a copper cathode is relatively low, being approximately

from about 1·8 to about 2·0 volts at 20° C. at an anode current density of about 20 amperes per square foot. This feature is of particular importance in the electrolytic production of copper, since it is instrumental in determining the terminal voltage which must be applied to the electrolysing cells. The cost of electrolytically precipitating copper from an electrolyte is proportional to the voltage which must be applied, and from the standpoint of commerical economy it is of the utmost importance that the surface-tension voltage of the anode be as low as practicable. The cobalt-silicon electrode of the present invention, combining as it does a relatively low surface-tension voltage with very effective resistance to anodic corrosion, makes a very durable, economical, and satisfactory anode in the electrolytic precipitation of copper.

The Separation of Minerals.—At the meeting of the Midland Institute of Mining, Civil, and Mechanical Engineers, held in August at Sheffield, Stanley Nettleton read a paper describing his method of separating minerals, based on their varying coefficients of friction. The paper dealt with the separation of stone from coal, but the principle is equally applicable to ore-dressing.

In the preparation of minerals for the market or for metallurgical treatment, it is generally necessary at some stage of the process for a sliding movement to take place on a hard surface of metal or other material. This sliding may take place in screening and in simple transit from one part of the plant to another, and these sliding effects may be utilized in order to separate one class of mineral from its natural associates of lower value. The inclination necessary to cause material to move upon a sloping surface is governed by a number of factors which have received attention from manufacturers of mining appliances, but the question of angle of slope appears to be generally solved by empirical methods. It has been found by experience that small material, say, of ½ in. diameter, requires greater inclination to cause movement than pieces, say, 1 or 2 in. in diameter, and that unscreened mineral which consists of fragments of all sizes down to particles of dust does not move so freely down a sloping surface as mineral which has been classified into grades of approximately equal sizes. The presence of moisture usually tends to hold up unscreened mineral on an inclined surface, but its effect is modified in the case of closely-sized material such as nut coal, ranging from 1 in. to 1½ in. in diameter. As crushing is a prominent feature in ore-treatment, reduction in size of mineral is rarely disadvantageous, and for this reason chutes and screens at metalliferous mines are generally placed at inclinations much in excess of that necessary for free movement in order to avoid the possibility of holding up any of the mineral.

Data on the slope necessary to overcome the coefficient of friction of minerals is meagre, but the subject has been referred to by several authors. Professor Henry Louis states, in "Dressing of Minerals," that "it is necessary to distinguish between the angle at which a mineral just commences to slide, and that at which it continues to slide at a uniform velocity after it has started from rest." He gives the result of determination upon moderately large lumps of various minerals sliding upon a smooth steel plate. From his table it may be assumed that the slope necessary to initiate movement may be anything from 24° to 31¼°, or 4° to 11¼° more than that which will maintain motion after a mineral has commenced to slide on an inclined plane. Materials such as quartz, coal, and limestone vary so much that some information is desirable on the physical character of the specimen tested. Limestones may be soft and friable or hard and semi-crystalline. The term "coal" includes materials varying in specific gravity from 1·15 to 1·45, and of widely different physical character. Gas-coal frequently breaks into fragments of more or less cubical form; cannel coal has often a semi-conchoidal fracture; anthracite breaks very irregularly, and lamellar structure is not unknown in lignitic coal.

Form, size, specific gravity, and hardness may each have an influence on the angle of slope at which a piece of mineral will commence to move or continue to move when placed on a smooth surface. Breakage is a matter of importance in the handling of coal, and the friction coefficient may be a factor used in the dry separation of coal from shale. In order to determine the principles underlying the behaviour of coal and the rocks with which it is associated in the mine, a large number of experiments were made on the lines here indicated. Samples of materials were broken and separated into classes of approximately similar sizes by screening; wire screens with square meshes of $\frac{3}{16}$, $\frac{3}{8}$, and $\frac{5}{8}$ in. were used to make three classes. It should be noted that closeness of sizing is governed to a considerable extent by the form which each mineral assumes when broken. Shales have a tendency to break into pieces in which the length and breadth are disproportionate to the thickness, while pieces of coal and anthracite usually assume a more or less cubical or spherical form. For this reason, on shaking coal and shale over a ½ in. mesh, the shale passing through the screen will contain more pieces over ½ in. in length than is the case with coal-sizing.

A small quantity of sized material was placed gently upon an inclined sheet of plate-glass, which was tapped three times in each experiment. There was then noted the proportion of material which slid off the inclined plane. Results were apt to be rather irregular, particularly near the points at which the material did not move at all, or the whole of it slipped off the glass.

The following is an example of a test. A large number of pieces of Yorkshire bituminous coal were placed on a sheet of glass 36 in. in length at an angle of 22°. In placing material on the inclined surface, each particle was put in contact with the medium over which it was to slide, so that carrying and packing effects were eliminated as far as possible. The size of the coal was through $\frac{5}{8}$ in. and over $\frac{3}{8}$ in. mesh, and the percentages of pieces of coal which moved to the bottom of the plate on tapping in nine experiments in these tests were 75, 85, 75, 70, 65, 80, 70, 75, 70. Average, 74%.

About 700 experiments were carried out on a considerable number of pieces of mineral. Large numbers of pieces were used in each of these experiments and averages were taken, in preference to a small number of carefully selected specimens being used which would have given more concordant results. Owing to the irregular nature of the materials dealt with in practice it was believed that the former method would give the more useful results, although these results would be of a more relative character. It was found from these that

the sliding of minerals over plane surfaces appears to be subject to the following laws : (1) Large pieces of coal have a less coefficient of friction than smaller ones ; that is, when set in motion they will continue to slide over a plane which is at a lower inclination. (2) Material which is freshly broken does not slide so readily over a smooth surface as material which has been standing some time before it is dealt with ; apart from the well-known fact that different minerals have different coefficients of friction.

The force in these experiments tending to move a particle may be taken as the component of the weight parallel to the plate ; that is, the weight multiplied by cosine of the angle of inclination of the plate. The principles deduced have been found equally applicable to the sliding of minerals on steel surfaces.

In introducing his paper, Mr. Nettleton said his object was the separation of coal from shale by mechanical means. If they could have a machine which would deal with the friction effect in such a manner that shale could be picked out of coal, they would have got something of value to the mining community. These friction effects were relative, and not absolute. If they put a quantity of anthracite and shale upon a plate inclined at an angle of 19°, 95% of the anthracite would slide off, but only 5% of the shale ; so that they would obtain a method of separating the anthracite from the shale. But, supposing the slide was taken at 20°, and vibrated so that the anthracite moved, then all the anthracite would be moved off ; but only about 12% of the shale would move. Taking then a case where they had 10% of dirt in an anthracite, they would find all the anthracite would be removed, while only 5% of the 10% of dirt would be removed. They would thus get only 5% of the 10%, a negligible quantity, of dirt remaining in the cleaned coal. These results were taken on the sliding effects upon a glass plate, but glass had the same frictional effects, though in a rather different degree as steel. It would, however, be impracticable to have a long steel slide over which material had to be shot, owing to the cumbrous nature of that arrangement. They could increase the friction by passing the material down a moving surface, such as a belt, so arranged that during the passage over 10 in. of space the dirt would move upwards, say, 50 in. By that effect they would get 60 in. of friction on the belt. The next point would be to obtain some means of removing the material or avoiding colliding effects, and he got over that difficulty by dividing the path of friction into two portions, one in a straight line and the other in a moving surface, which, for practical purposes, was most convenient in a rotating steel disc.

The author exhibited a small experimental model, in which a steel disc, 2 ft. in diameter, was rotated by a motor, and material was fed down a spout on to the disc. The coal went straight forward across the disc, while the shale turned off at an angle. When an arrangement of that kind was fixed up on satisfactory engineering principles, he said, it was possible to get almost a perfect separation of anthracite, say, from associated shale. By using the two sides of the disc, they would double the capacity of the machine, and if they had a vertical shaft it was possible to have a number of discs on that shaft, 6 ft. or 8 ft. apart, and it should then be possible to multiply the efficiency of the machine twenty times. Further reference will be made to this paper in a future issue.

Hyde's Welding Process.—*Engineering* for September 2 contains an account of a process of welding invented by A. C. Hyde, of the Hyde Welding Co., Wolverhampton. By this process two pieces of steel are joined together by means of copper which permeates the surfaces and forms an alloy of iron and copper. The secret of getting copper into such a fluid state as to enable it to penetrate the finest cracks and to start molecular action is to melt it in an atmosphere of hydrogen. The hydrogen reduces any oxide on the iron or steel, and it also has the remarkable effect of making the molten copper as fluid as petrol. The copper immediately spreads over the surface in an extremely fine film and penetrates the space between the parts to be joined. It is stated that the joints obtainable in this way are strong and reliable. Presumably the fluidity of the copper is explained by the principle of surface tension, and scientific investigation of the phenomenon would be of great interest.

Determination of Vanadium.—The *Journal of Industrial and Engineering Chemistry* for August contains a paper describing a method for the determination of vanadium in ores and metallurgical products, written by R. B. Schaal, of the Firth-Stirling Steel Co., McKeesport, Pennsylvania. The author has found the modification of Johnson's method previously used at these works uniformly low. The method here described is believed to meet all the requirements of accuracy, speed, ease of execution, and economy so necessary for routine and general use. The method depends upon the reduction of vanadic acid, by prolonged boiling with strong hydrochloric acid, to the tetravalent condition, and subsequent reoxidation with a suitable solution of potassium permanganate to the pentavalent state. The reaction involved are well known, and may be stated as follows :—

$$V_2O_5 + 2\,HCl = V_2O_4 + H_2O + Cl_2$$
$$5V_2O_4 + 2KMnO_4 + 6HCl = 5V_2O_5 + 2KCl + 2MnCl_2 + 3H_2O.$$

This reaction is found to run to completion with a sharp end-point, in a nearly neutral solution containing a suitable excess of ammonium phosphate, and admits of the presence of large amounts of iron, chromium, molybdenum, cobalt, nickel, uranium, titanium, or zirconium, besides the amounts of manganese usually present in all samples. The colour of ferric chloride is destroyed by the ammonium phosphate. Chromium, because of its deep green colour, tends to obscure the end-point. This fact offers no difficulty to the chemist familiar with the determination of chromium by the ferrous sulphate-permanganate method, the end-point appearing as faint old rose reflections through the green. The use of an ordinary Mazda lamp behind a white screen clarifies the end-point to a remarkable degree, and the use of this device is recommended for all samples containing 3% or more of chromium. Molybdenum has been present in tests to the extent of 10%, and apparently interferes in no appreciable manner. As the reduction of the vanadium by hydrochloric acid is selective with respect to molybdenum, this element remains in the oxidized state and is not affected by permanganate under the conditions obtaining in the titration. Cobalt and nickel have been added in amounts up to 5% of each, the only effect being the production of a slight green colour. Elements whose phosphates are insoluble, or partly so, under the given conditions, notably uranium,

[illegible] steam, cloud the solution, but do not otherwise interfere. If present in appreciable amounts, the precipitates may be removed by filtration. By far the most important effect of the ammonium phosphate is that of converting any excess hydrochloric acid present, above the amount actually needed for the completion of the reaction, into the less highly ionized phosphoric acid, and thus minimizing the danger of reaction between the excess acid and the potassium permanganate. It should be pointed out that excessive cold slows the reaction unduly. If conducted at 20° C., however, the reaction proceeds with a rapidity which leaves nothing to be desired. The end-point does not disappear, as is the case in titrating cold sulphuric acid solutions, so slowly as to leave doubt as to the precise end of the reaction, but becomes permanent at once.

SHORT NOTICES

Estimation of Zinc.—In the *Journal of Industrial and Engineering Chemistry* for August, M. Bodansky gives a method of determining extremely small quantities of zinc.

Concentration Problems.—In the *Engineering and Mining Journal* for August 27, E. S. Wiard commences a series of articles on preliminary roughing concentration by sorting, jigging, and tabling.

Nevada Consolidated. — In the *Mining and Scientific Press* for September 4, A. B. Parsons gives a detailed description of concentration at the mill of the Nevada Consolidated Copper Company.

Electric Furnaces.—In *Chemical and Metallurgical Engineering* for September 7, J. Herlenius writes on electric furnaces adapted to the melting of gold, silver, and other metals of low melting point.

Permanganates. — The *Journal of Industrial and Engineering Chemistry* for September contains a paper by Wilson, Horsch, and Youtz describing the experimental electrolytic production of permanganates of soda and potash from ferro-manganese anodes.

Carbonic Oxide.—In the *Journal of Industrial and Engineering Chemistry* for September, C. R. Hoover gives methods of detecting small quantities of carbonic oxide, small but sufficient to give unpleasant physiological effects.

Aluminium.—In the *Journal of Industrial and Engineering Chemistry* for September, J. H. Capps gives a method for estimating the oxygen content in commercial aluminium.

Cornish Tin Lodes.—The September *Bulletin* of the Institution of Mining and Metallurgy contains a paper by H. B. Cronshaw on the structure and genesis of some tin lodes in the Camborne district.

Octagonal Shaft.—A paper was read at the September meeting of the American Institute of Mining and Metallurgical Engineers by J. L. Bruce, giving particulars of a circular shaft lined with timber arranged octagonally.

Scottish Oil Boring.—At the meeting of the British Association held last month, H. M. Cadell read a paper entitled "Evidence from Recent Bores in the Carboniferous Rocks of Scotland."

Stope-Filling.—A paper on hydraulic stowing in coal mines, by Professor George Knox and J. Drummond Paton, appears in the *Proceedings* of the South Wales Institute of Engineers, just published, and is reprinted in abstract in the *Iron and Coal Trades Review* for September 30.

Flotation applied to Coal.—A paper on the froth-flotation of coal, by F. B. Jones, appears in the *Proceedings* of the South Wales Institute of Engineers, just published, and is reprinted in abstract in the *Iron and Coal Trades Review* for September 30.

RECENT PATENTS PUBLISHED

☞ *A copy of the specification of any of the patents mentioned in this column can be obtained by sending 1s. to the Patent Office, Southampton Buildings, Chancery Lane, London, W.C. 2, with a note of the number and year of the patent.*

10,561 of 1920 (141,733). M. M. Merritt, South Middleton, Massachusetts. Improved electrolytic plant for coating steel wire with copper.

10,573 of 1920 (151,236). W. E. Trent, Washington. A process of treating materials having a carbonaceous content, more especially coal, lignite, and the like, which consists in subjecting the material in a fine state of subdivision suspended in water to the action of a hydrocarbon having the property of forming a dense agglomerate with the carbonaceous particles to the exclusion of the water and non-carbonaceous particles.

10,895 of 1920 (168,097). E. E. Naef, Nottingham. Method of removing sulphur from copper-nickel matte by melting with caustic soda.

10,929 of 1920 (168,098). L. A. Wood and Minerals Separation, Ltd., London. In the flotation of oxides such as cassiterite, introducing carbonic acid gas into the agitated pulp for the purpose of preventing other gangue minerals rising.

12,486 of 1920 (142,847). R. Walter, Villach, Austria. Improved method of making acid-proof alloys of silicon with iron, nickel, and chromium.

13,786 of 1920 (167,863). Allis Chalmers Manufacturing Co., Milwaukee. A roasting furnace subdivided into a number of sections or hearths, separated by doors, and arranged at different levels, each section being provided with an independently operable set of rabbles.

15,278 of 1920 (167,904). R. de H. St. Stephens, Camborne, and A. Ewing, London. Improvements in the construction of rock-drills, particularly in regard to the feed of water by preventing any admixture of air with the water, so that atomization or spraying is prevented, and the flushing out of the hole by the water is rendered more efficient. The tube conveying the water to the drill steel is arranged coaxially with the drill steel and the piston, and is held fixed in the anvil block into which the head of the drill steel fits, while the piston slides over the tube and the end of the tube beyond the piston works through packing in a gland. With this construction the water flows through a closed tubular path to the drill steel, and any entrance of air into the tube, or leakage of water therefrom is prevented.

17,723 of 1920 (145,585). W. North, Hanover. Electrostatic precipitation of dust from gases.

20,316 of 1920 (148,388). R. E. Bea, Paris. Electric furnace for obtaining copper and oxide of zinc from old brass.

28,429 of 1920 (167,980). E. Leclercq, Haine St. Paul, Belgium. Improvements in hammer drills, wherein the air-distributing chamber, instead of being arranged at the end of the cylindrical body of the drill and within it, is arranged laterally

of said cylindrical body. The distributing chamber is arranged between the body of the drill and a laterally projecting handle, and is divided by a partition into two compartments, one of which contains an automatic ball-valve mechanism, while the other contains a sliding member, actuated from the outside by means of a pivoted thumb-lever to control the feed of compressed air from the air conduit in the handle.

29,191 of 1920 (168,205). L. F. RICHARD, Edinburgh, and R. G. D. SMALL, London. Improvements in rollers for guiding and supporting haulage cables in mines, etc.

6,783-4 of 1921 (167,725-6). A. H. EUSTIS, Norfolk, Massachusetts. Improvements in the inventor's process for recovering sulphurous acid from furnace gases.

NEW BOOKS, PAMPHLETS, Etc.

☞Copies of the books, etc., mentioned below can be obtained through the Technical Bookshop of *The Mining Magazine*, 724, Salisbury House, London Wall, E.C. 2.

Barium Minerals 1913–1919. Pamphlet, 26 pages. Price 9d. Published by the Imperial Mineral Resources Bureau.

Lead and Zinc Ores in the Carboniferous Rocks of North Wales. By BERNARD SMITH. Paper covers, octavo, 162 pages, illustrated. Price 5s. 6d. net. Vol. XIX of the Special Reports on the Mineral Industry of the United Kingdom, published by the Geological Survey.

Lead, Silver-Lead, and Zinc Ores of Cornwall, Devon, and Somerset. By HENRY DEWEY. Paper covers, octavo, 72 pages, illustrated. Price 2s. 6d. net. Vol. XXI of the Special Reports on the Mineral Industry of the United Kingdom, published by the Geological Survey.

Lead and Zinc Ores of the Lake District. By T. EASTWOOD. Paper covers, octavo, 60 pages, illustrated. Price 2s. net. This is Vol. XXII of the Special Reports on the Mineral Resources of Great Britain prepared by the Geological Survey.

Transvaal Chamber of Mines 31st Annual Report, 1920. Cloth, quarto, 270 pages. Published by the Chamber at Johannesburg, and at the London offices of the Chamber, Salisbury House, E.C. 2.

The Working of Steel; Annealing, Heat-treating, and Hardening of Carbon and Alloy Steel. By F. H. COLVIN and K. A. JUTHE. Cloth, octavo, 250 pages, illustrated. Price 18s. net. New York and London: McGraw-Hill Book Co., Ltd.

COMPANY REPORTS

New Modderfontein Gold.—The report of this company operating one of the two greatest gold mines in the Far East Rand, covering the year ended June 30 last, shows that 1,222,266 tons of ore was raised, and that after the removal of waste 1,083,100 tons, averaging 9·96 dwt. gold per ton, was sent to the mill. The yield by amalgamation was 347,855 oz., and by cyanide 179,622 oz., making a total of 527,477 oz., being 9·74 dwt. per ton. The par value of the gold produced was £2,240,000, or 40s. 11d. per ton, and the amount realized was £2,969,198, or £54s. 10d. per ton. The working cost was £1,270,146, or 23s. 5d. per ton, leaving a working profit of £1,699,051, or 31s. 5d. per ton. The shareholders received £1,400,000, the distribution being at the rate of 100% The yield per ton was about ½ dwt. less than during the previous year. The tonnage milled was 114,000 higher. The working cost per ton was up 1s. 6d. On the other hand, the premium realized on the sale of the gold was much higher than during the previous year, accounting for £751,427 out of the total profit of £1,699,051. The development operations have continued to disclose valuable ore. In particular high-grade ore over a wide stoping width has been found in the area west of No. 2 shaft between the 12th and 13th levels. This is the most important discovery in this section of the mine. The developments in the eastern side of the mine have continued to fulfil expectations. The total ore developed throughout the mine during the year was 1,234,100 tons, averaging 10·5 dwt. per ton. The reserve is estimated at 8,884,600 tons, averaging 8·4 dwt. per ton, figures much the same as those of the previous year. It will be observed that the grade of the ore treated continues to approximate more closely to the ore developed than to the average grade of the reserves.

Modderfontein East.—This company belongs to the Central Mining-Rand Mines group, and was formed in 1917 to acquire a new lease area in the Far East Rand and to amalgamate this with the properties of the Cloverfield and Rand Klip companies. Development is proceeding from No. 1 shaft in the Cloverfield area and from Nos. 2 and 3 shafts in the leased areas. The report for the year ended June 30 last shows that 20,270 ft. of development was done, of which 15,934 ft. was on the reef. Of the reef sampled 51% proved payable, and the reef disclosure was 8,130 ft., 25 in. wide, averaging 15·8 dwt. per ton. The best ore has been found round No. 1 shaft, that at Nos. 2 and 3 being of medium grade. The total ore reserve is estimated at 1,611,700 tons, averaging 7·7 dwt. over 57 in. During the year 296,987 tons of ore was raised, and this, together with 91,928 tons from the dumps, was sent to the sorting stations, when 23% was sorted out as waste. The amount sent to the mill was 299,800 tons, averaging 9·04 dwt. per ton. The yield of gold by amalgamation was 57,397 oz., and by cyanide 61,541 oz., making a total of 118,938 oz. The revenue from the sale of the gold was £662,699, or 44s. 6d. per ton, and the working cost £452,910, or 30s. 5d. per ton, leaving a working profit of £209,789, or 14s. 1d. per ton. The expenditure on capital account during the year was £379,579, of which development represented £110,480, and plant most of the remainder. New shares were issued, bringing in £317,136. The ore is still being shipped for treatment to the Apex plant, which is held on lease. The plant of the Simmer Deep and Jupiter companies has been purchased, but its erection on the spot is deferred until financial conditions improve.

Nourse Mines.—This company belongs to the Central Mining-Rand Mines group, and operates a gold mining property in the central part of the Rand. The report for the year ended June 30 last shows that 560,009 tons was raised, and after the removal of 9% waste, 508,350 tons averaging 6·58 oz. per ton was sent to the mill. The yield of gold by amalgamation was 103,155 oz., and by cyanide 57,344 oz., making a total of 160,499 oz. The sale of the gold realized £903,318, of which

£28,915 accrued from premium. The working cost was £284,970, leaving a working profit of £18,837. The revenue per ton milled was 35s. 6d., the cost 30s. 10d., and the profit 4s. 8d. Of the revenue per ton 9s. represented premium. It will be seen that but for the premium, a considerable loss would have been incurred. The ore reserve has been maintained, and stands at 1,589,030 tons, averaging 6·9 dwt. per ton.

Consolidated Main Reef.—This company was formed in 1896 as a consolidation of other companies that had operated in the middle west Rand since 1888 and 1893 respectively. On the death of Sir S. Neumann the control was taken over four years ago by the Central Mining and Investment Corporation. In 1918 the adjoining Main Reef West property was absorbed. The report for the year ended June 30 last shows that 634,705 tons of ore was raised, and after the removal of 11% waste, 561,800 tons, averaging 7·39 dwt. gold per ton, was sent to the mill. The yield by amalgamation was 144,250 oz., and by cyanide 52,454 oz., making a total of 196,704 oz. The gold realized £1,105,077, of which £282,724 accrued from premium. The working cost was £905,952, leaving a working profit of £199,124. The revenue per ton milled was 39s. 4d., the working cost 32s. 3d., and the working profit 7s. 1d. Shareholders received £155,950, the dividends amounting to 12½%. It will be seen that if it had not been for the gold premium the year's working would have resulted in a loss. As compared with the previous year, the yield per ton was about 0·7 dwt. less, while the cost went up 3s. 1d. As regards ore reserves these are calculated at 1,176,500, averaging 7·5 dwt. per ton, as against 1,186,000 tons averaging 7·6 dwt. Development during the year maintained the total reserve, but it is stated that this was in the nature of selective development in the most promising part of the mine, and that in other parts it will be necessary to press development without delay. If no large amounts of ore are found in other parts within the next year or so it is feared that the scale of extraction will have to be reduced.

Transvaal and Rhodesian Estates.—This company was formed in 1911, and conducts a land and mining business in various parts of South Africa. The chief mining interest is the Fred gold mine in the Filabusi district of Rhodesia. The report now issued covers the year 1920. During this time 18,950 tons of ore was milled at the Fred mine for a yield of 13,971 oz., being an extraction of 14·75 dwt. per ton. The working profit not allowing for depreciation was £29,324. The reserve at the end of December was 48,350 tons, averaging 16·2 dwt. per ton. The accounts of the company show a balance of profit of £22,402, which is carried forward.

Mount Morgan.—The report of this Queensland gold-copper mine for the half-year ended May 31 shows that operations were continued until the Easter holidays, March 24, after which the low price of copper made it inadvisable to resume operations. During the period of activity 87,719 tons of ore was raised, of which 26,852 tons was smelting ore and 60,712 tons concentrating ore. At the concentrating plant 60,907 tons averaging 1·95% copper and 6·1 dwt. gold per ton was treated, the products being as follow: 8,303 tons of jig concentrates averaging 1·93% copper and 6·65 dwt. gold, 8,205 tons of table concentrates averaging 3·61% copper and 13·1 dwt. gold, and 4,089 tons of flotation concentrates averaging 15·8% copper and 28·25 dwt. gold. At the smelter 50,108 tons of material was treated, yielding 1,697 tons of copper and 23,777 oz. of gold. This material consisted of 30,537 tons of ore, which yielded 2·43% copper and 7·35 dwt. gold per ton, 7,837 tons of jig concentrate, 9,563 tons of sintered table and flotation concentrates, and 2,118 tons of Many Peaks ore. On May 31 the reserve of ore was estimated at 3,257,287 tons, averaging 2·57% copper and 6·04 dwt. gold per ton. The accounts showed an income of £372,571 and a net profit of £13,884 for the half-year

Anantapur Gold Field.—This company was formed in 1906 by John Taylor & Sons to acquire old workings in the Anantapur district, Madras Presidency, South India. Parts of this property have been worked by subsidiary companies, the North Anantapur Gold Mines, Ltd., and the Jibutil (Anantapur) Gold Mines, Ltd., shares in which are still held by the present company. The report for the year ended March 31 last shows that dividends, interest, etc., brought an income of £2,395, against an expenditure of £973. At the North Anantapur exploration is being done on the 950 ft. level south of No. 5 shaft, but so far with no result, while at the Jibutil development is in hand for exploring the lode at and below the 500 ft. level from No. 1 Prospect shaft. Nothing is being done on the company's own sections of the goldfield. The directors are considering the acquisition of shares in a gold-mining syndicate about to be formed to test other properties, on which a favourable preliminary report has been received.

Arizona Copper.—The report of this Edinburgh company operating at Clifton, Arizona, for the year ended September 30, 1920, shows that 1,046,331 tons of ore was raised, coming from the individual mines as follows: Humboldt, 739,806 tons; Clay and Petaluna, 180,948 tons; Yavapai, 37,053 tons; Coronado, 51,121 tons; Horse-shoe, 5,941 tons; lease ores, 31,462 tons. Of this amount 1,012,040 tons was concentrating ore averaging 2·08% copper. The concentrate averaged 6·97% copper, and the recovery was 75·5%. The smelter treated 147,206 tons, and the output of copper was 17,846 tons (of 2,000 lb.), of which 13,882 tons was electrolytic and 3,964 tons bessemer. The output was less than normal, owing to curtailment of operations due to the inability of producers to market their copper. The accounts for the period showed a loss of £319,672, but against this was £292,373 excess profit duty refunded and £96,575 reduced provision for United States taxes, so that there was an actual profit of £69,275. The company also issues a report for the eight months ended May 31, 1921, at which date output was suspended owing to the continued fall in demand and price. During this time 573,397 tons of ore was raised, averaging 2·15%, which on concentration yielded material averaging 7·84%, with a recovery of 75·3%. The smelter treated 80,710 tons, and produced 9,275 tons of copper. Experiments on flotation and on the treatment of the ores of lower grade have been continued and many improvements have been introduced or suggested. The accounts for the eight months show a deficiency of £254,277. Reference is made in the Editorial columns to the negotiations for the sale of the company's property to the Phelps-Dodge Corporation.

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EDITORIAL

IS it too late to ask the authorities to reconsider their decision to hold the Great Exhibition of 1923 at Wembley Park? Surely this site is not sufficiently accessible. Many potential exhibitors are hesitating for this reason.

DR. J. D. FALCONER, the Director of the Nigerian Geological Survey, is giving a series of lectures on the Wonders of Geology at the Imperial College of Science, South Kensington. Many of our readers will no doubt be glad to know of these lectures, for they fill a gap between a college course and lectures interesting only to specialists. There is no charge for the course.

OWING to an error of transcription the monthly output of Trinidad Leaseholds, Ltd., was given as 15,000 *barrels* instead of *tons*, in the article by Mr. H. B. Milner on the Trinidad oil industry in the October issue, p. 211. As this company is the largest individual producer on the island, this error of units is particularly unfortunate. We hope all who keep the MAGAZINE will make the correction.

THE approaching Conference of the Powers at Washington is of direct interest to mining engineers, as one of the subjects to be discussed is the "open-door" in the development of the world's oilfields. The average Englishman's attitude in this matter is clear. He does not wonder that the British Government and the British and Continental oil companies have felt compelled to protect themselves against the notorious tactics of the Standard Oil Company.

ON the 24th of this month Earl Haig is to unveil the Memorial to the members of the Institution of Mining and Metallurgy who fell in the war. This Memorial has been designed and executed by Colonel P. N. Nissen, whose artistic modelling is already well known among mining men. We postpone a detailed description until after the ceremony of unveiling, but in the meantime it may be mentioned that the sculptures are unconventional, realistic rather than symbolic, and in that way appeal strongly to the emotions of those who know the nature of the work which their dead friends did in the war.

ABSTRACTS of several articles on petroleum appear in our Mining Digest this month. Of these, the description of the Southern Mexican oilfields will be of particular interest to investors and users of petroleum, for it presents the question in a more reassuring manner than many recent articles on the subject. Dr. Hume's historical account of the Egyptian oilfields fills a gap in the general literature of oil technology, for hitherto published information on these oilfields has appeared in official reports issued by the Egyptian Government, which are not easily accessible to the public. A third article, written by Mr. H. W. Hixon, deals with speculations as to the origin of petroleum. Mr. Hixon is a distinguished metallurgist, who is noted for unorthodox and daring views in the domain of economic geology. He takes the side of the inorganic theory of the origin of petroleum, and in this article he gives some of his reasons for adopting this view. He is, of course, in a minority, for perhaps only he and Mr. Eugene Coste argue that all petroleum comes from an inorganic source. Mr. Coste expounded his arguments in a paper read before the Institution of Mining and Metallurgy in October, 1911, so it is not necessary to quote him here. Other oil geologists, while admitting the possibility of forming a series of hydrocarbons from inorganic substances, are disposed to attribute the origin of most of the petroleum so far known to an organic source, particularly from the animal kingdom. They rely largely on the analogy between oil and coal, and nobody doubts the vegetable origin of coal. There is one point in Mr. Hixon's argument which we do not follow. He says that an oil containing no oxygen cannot come from an organic source, and that neither could an oil which is poisonous to life. In reply, we would say that oils are obtained containing no oxygen and poisonous to life by the distillation of coal, which is admittedly of vegetable organic origin, so no reason can be given for supposing that hydrocarbons cannot be obtained from an animal organic origin by means of some heat treatment. Though the inorganic origin of petroleum has few supporters among geologists the theory is sound enough in itself, and it only suffers owing to the presence of one more obvious. Arguments in favour of the inorganic theory are always welcome in these pages.

The Russo-Asiatic Negotiations

As has been recorded already in these pages, Mr. Leslie Urquhart and his co-directors of the Russo-Asiatic Consolidated, which owns by right the Kyshtim, Tanalyk, Ridder, and Ekibastus mining properties in the old Russian Empire, have been in negotiation during most of the current year with the Soviet Government or its emissaries, with a view to obtaining a return of the concessions and permission to recommence operations. Mr. Urquhart was in communication with the Soviet emissary in London, M. Krassin, for several months, and after full discussion and reference to headquarters in Moscow a tentative agreement was reached. The position was so favourable that Mr. Urquhart left for Moscow on August 14. From the time of his arrival, August 20, to September 12 he was continuously engaged in discussing the proposed contract with the Technical Economic Commission, which was appointed by the Soviet Government for this specific purpose. This Commission was a large one, and included many men who were of commercial and professional standing before the revolution. The Commission had only advisory duties, for the decision on each point was really vested in three High Commissioners, Ministers of the Soviet Government, who, in turn, had to submit the draft contract to the final decision of the Council of the People's Commissaries, under the presidency of M. Lenin. The draft contract contained twenty-seven clauses, of which eighteen were agreed by both parties. The remaining nine, as drawn up by the Soviet Government, could not possibly be accepted by Mr. Urquhart, and any suggestion or expostulation on his part was ineffective in securing a satisfactory modification. He returned to London, and, after discussion with his co-directors, placed his views and experiences before M. Krassin. Subsequently he addressed a letter to M. Krassin, putting on record an account of the stumbling-blocks in the way of agreement with the Soviet Government. This letter has been circulated widely among shareholders in the Russo-Asiatic Consolidated, and among the public generally. It gives not only the details of these particular negotiations, but it reflects by means of this specific case the actual attitude and ideas of the party at present in control in Russia and Siberia.

Space forbids us giving anything like full quotations from this letter, but one or two points may be mentioned. For instance, the royalties to be paid on sales of products were outrageously high, not only sufficient to wipe out any possible profit, but to cause serious continuous losses to the company. Then, again, the Government refused to forgo their absolute control of labour, both skilled and unskilled, Russian or foreign, and asserted their right to labour or military conscription, irrespective of the regular occupations of the workmen and staff. Under such a regime any local organization of the Soviet Government could take a Russian employee, a professional man or a highly skilled workman, away from his job, and set him to clean the streets.

The crucial test of the value of the contract arose during the discussion of the arbitration clause. At first sight, the proposal that all disputes and misunderstandings as to the carrying out of the contract should be referred to a permanent arbitration commission of three, one from each side and one neutral or foreigner, should be acceptable, but Mr. Urquhart soon found from the discussion that such a Commission would be ineffective, because the so-called State recognizes no contract between individuals. Communism does not recognize the right to private property on which the previous civil and criminal code was based, so magistrates have been suppressed and courts of justice have been abolished. Nothing has been substituted for these, except a "Court of Revolutionary Conscience." Under the new system taxes have been abolished, as have all laws and regulations relating to mining, factories, customs, forestry, and railways, and their place has been taken by incomplete decrees and instructions issued from day to day. Furthermore, the communistic system does not recognize any obligations between individuals; thus no contract between two persons can be enforced. Nor does the State itself recognize obligation on its part towards individuals or subjects; on the other hand, everybody is in absolute subjection to the State. Thus it is obvious that the Arbitration Commission would have virtually no status. The position of a neutral or foreigner on the Commission would be impossible, for the Soviet Government, even if it consented to his presence, would hardly bow to his advice. As for referring disputes to the Court of Revolutionary Conscience, this could not be accepted by

Mr. Urquhart, for the members of that court are admittedly communists, and are of none too high intelligence, and are lacking in legal training. Obviously their judgments would always be prejudiced against capital.

In his letter to M. Krassin Mr. Urquhart also makes reference to the increasing powers of the Secret Police, otherwise the Che-ka, or Extraordinary Commission for Combating Counter Revolutions. This organization was originally started for the purpose of enforcing the communistic system on the unwilling people, but it subsequently developed into a sort of predatory body, accuser, judge, jury, and executioner all in one, with absolute power of life and death, responsible only to M. Lenin and the communistic leaders. The Soviet Government itself is at the mercy of this body, and any of its decrees may be rendered ineffective by Che-ka, if the communistic controllers think fit.

Altogether the position in Russia is such that no commercial undertaking has a ghost of a chance of success, and the hopes entertained by Mr. Urquhart of re-establishing his mining enterprises by the aid of the Soviet Government have been rudely dashed. How Russia is to be saved and the control of the country placed in better hands is at present an insoluble problem.

Ventilation and Efficiency

In the current issue we publish the first half of an article by Mr. Bernard W. Holman, Lecturer in Mining at the Royal School of Mines, on "Ventilation and Working Efficiency." During the last few years the scientific aspect of working conditions in respect of dry and cool air has received considerable attention in this country, more particularly in the workshops and factories, and also more recently in the coal mines. But among metal miners the subject has not been widely studied on the same lines. The credit for the introduction of these scientific investigations at gold mines is due to Messrs. Orenstein and Ireland, who have conducted many experiments on the Rand. Perhaps it would be more correct to say that they were the first to give the public the benefits of their results, for it is probable that the studies were started at an earlier date by the engineers of the St. John del Rey Company. In the latter case, however, very little has been published. In a paper read early this year before the Institution of Mining and Metallurgy on the new shaft at the City Deep, Mr. E. H. Clifford discussed the question in detail, and whetted the appetite of English mining engineers for more on the same subject and for an exposition of the underlying principles, starting as it were from the beginning. Many members of the Institution appeared to have forgotten that an article on the subject by Mr. David Penman had appeared in the MAGAZINE for June, 1920. This article still holds good as a general introduction to the subject. It was felt, however, that further discussion of the principles was desirable, and readers will therefore be glad to have Mr. Holman's critical paper on the scientific questions involved. A great deal of literature has appeared in this and other countries, usually written by medical men and seldom by mining engineers. Their books, reports, pamphlets, and articles are scattered, and are not easily traced or obtained, and when they have been secured the metal-mining engineer finds considerable trouble in picking out his requirements from among the vast multitude of records and arguments. Readers of the MAGAZINE will therefore be greatly indebted to Mr. Holman for presenting the questions in logically consecutive order and for unravelling so many complicated and often contradictory views and arguments. In the second section of his article there will be included a bibliography that will indicate the lines on which further and special study may be pursued.

This subject is still further impressed on the mining engineer by the paper, read at the meeting of the Institution of Mining and Metallurgy held on October 27, by Dr. Leonard Hill, the pioneer of the study of the science of ventilation and the inventor of the kata-thermometer, a small instrument somewhat like a clinical thermometer, intended for the purpose of estimating the comparative rapidity of the cooling effect of air on the human body. Those who attended the meeting had the additional privilege of hearing some interesting remarks by Dr. J. S. Haldane, another great authority on atmospheric conditions as affecting efficiency of work. Dr. Hill and Dr. Haldane differ considerably in some of their views, or at least in their method of applying and emphasizing details. Dr. Hill is a believer in sunlight and fresh air, as well as in the prevention of an undue increase in body temperature. On the other hand, he has shown that low oxygen content of the air and high carbonic acid content are not necessarily

inimical to health. Dr. Haldane adduces evidence that the average coal miner is as healthy as the average agricultural labourer, and argues accordingly that comparative darkness and impure and dusty atmosphere are not necessarily harmful to the health and strength of the worker. He agrees with Dr. Hill on the question as to low oxygen content and high carbonic acid content in the atmosphere, but he also deprecates the objection to smoky and dusty atmospheres, arguing that the human system can easily adapt itself to variations in the composition of the atmosphere, and that dust and microbes give the phagocytes of the lungs excellent occupation and training. Dr. Haldane and Dr. Hill were agreed, however, on the main theme of the latter's paper, that is to say, the body temperature must never be allowed to rise unduly under any circumstances, though it is only recently that Dr. Haldane has agreed with Dr. Hill that air in motion rather than dry and cool air has the desired effect of lowering the body temperature.

The subject of ventilation and working efficiency, as discussed by Mr. Holman and Dr. Hill, is only one of the phases of the study of the human body in relation to ventilation and work. The presence of poisonous gases such as carbonic oxide, and of deleterious dust which overcomes the phagocytes, are equally important subjects of discussion; and if no reference is found to them in the papers mentioned it must be remembered that it is best to discuss one thing at a time.

Shetland Copper

In several issues recently we have made reference to the venture undertaken for the purpose of working the deposits of copper ore at Sand Lodge, near the southern end of the Mainland of the Shetland Isles. In the September issue an outline was given of the history of these workings extending over a century, and it was then shown that in spite of many efforts no satisfactory outputs had ever been obtained. Of the earlier operations there are only the barest records, and details as to the nature of the work done are not now available. It was not until the reopening of the mines in 1872 by Mr. John Walker that any reports were published. From that date to 1879, when the property was sold to the Sumburgh Mining Co., Ltd., a number of engineers examined the property, and their reports were sufficiently favourable to warrant the flotation of this company. Yet in 1881 we find the resident manager referring to the impossibility of making a profit on inferior ores with insufficient appliances, and urging that the shaft should be sunk deeper in order to find richer ore. The company did not raise the £5,000 which he recommended for the purpose of buying additional plant and sinking deeper, and the operations accordingly lapsed. The mines have been examined since then on more than one occasion, and various proposals for reopening have been made. The reports, however, were generally adverse, and nothing was done until 1920. It is interesting in this connexion to record that during the war the mines were suggested as a possible source of copper, but knowing their history the authorities at the Ministry of Munitions did not think it worth while even to examine the deposits.

As we have said, work at the mines was once more started in 1920. This was undertaken by the Shetland Exploration Syndicate, Ltd., which in August of this year transferred the properties to another company, the Sand Lodge Mine, Ltd. The reports on which the company was floated and the operations undertaken were made by Dr. J. B. Garbe. After the shafts had been unwatered and a fair amount of machinery bought, the directors heard something of the history of the mines, and considered it advisable before they went any further to have a second opinion on the properties. Mr. H. H. Yuill, M.Sc., M.Inst.M.M., a partner in the firm of Bainbridge, Seymour & Co., Ltd., was accordingly asked to make an examination He, with his assistants, made a study of the geology of the district and of the ore deposit, and systematically sampled the lodes. The result of his investigations was so unfavourable that work was immediately suspended and the project abandoned. His view, expressed in a few words, was that "there is no ore carrying payable values in copper in the Sand Lodge mine, and no mineral occurrences exposed in the underground workings or on the surface which indicate that payable ore would be disclosed by exploration work."

To give an idea of Mr. Yuill's reasons for coming to this conclusion, we give herewith a summary of his general statement. There are two parallel lodes, about 120 ft. apart, known as the West and East lode respectively. The West lode is from 7 to 12 ft. wide, and has been worked along the strike by open-

on, and by two inclined shafts sunk to a depth of 140 ft. At various times between 1798 and 1880 a total of about 10,000 tons of lode material has been extracted and sold as iron ore. A much smaller amount of copper ore and regulus was shipped. The lode material down to the 66 ft. level consists of spongy iron oxides, hematite or limonite, with nests of malachite in vugs. Below this level, the lode material gradually changes, until at 96 ft. it becomes crystalline siderite, associated with calcite and dolomite, and containing disseminated iron pyrites with some copper pyrites. The sampling of accessible portions of the stopes and drives gave an average copper content of 1·17% over a width of 80 inches. There is no workable tonnage of this ore developed and opened-up for stoping. The East lode has been developed by a vertical shaft and levels have been opened at 230 ft. and 275 ft. Drives extend along the lode in both directions on the 230 ft. level for a combined length of 380 ft. Of this length 80 ft. at the south end carries only traces of copper. Of the remaining 300 ft. the sampling gave 1·21% copper over an average width of 114 inches. There are no blocks of ore developed and ready for stoping on this lode.

As regards the character of the ore, it may be said that the ore extracted from the West lode was entirely iron ore, and that the copper content was always small. On the other hand, the East lode contains much sulphide. Iron pyrites is disseminated fairly regularly through the siderite, but the chalcopyrite occurs irregularly, sometimes on the walls of the lode and sometimes within the lode.

Mr. Yuill's report contrasts very strongly with those written by Dr. J. B. Garbe. Writing on April 4, Dr. Garbe mentions veins of rich copper ore varying in width from 15 to 24 inches, and carrying over 20% of copper, and veins of from 6 to 10 ft. of mixed ore averaging from 3 to 8% of copper. He also states that practically every foot of the development over 1,400 ft. at the 240 ft. and 300 ft. levels shows payable copper ore. He considers that the West and East lodes join at a point between the 240 ft and 300 ft. levels from the vertical shaft. On the other hand, Mr. Yuill's interpretation of the geology is to the effect that these are two parallel lodes and that there is no junction in depth. In estimating the ore reserves, Dr. Garbe takes a measurement for 500 ft. along the strike and the depths on the dip between the surface and the presumed junction of the lodes, reckoning the width of the East lode at 6 ft. and that of the West lode at 14 ft., and calculates that there is 369,000 tons of ore in sight, fully developed and ready for immediate mining.

The engineers who reported in 1879 appear to have made an assumption on somewhat similar grounds, though the general tone of their reports was not quite so favourable as those of Dr. Garbe. Dr. Garbe also says that the " mine is fully proved and developed, and is ready for stoping, with an immediate production of 1,000 tons of ore per week ; a production of 500 tons per week could be proceeded with almost at once, and 1,000 tons as soon as the equipment now being erected and prepared is completed."

The treatment of the ore is by no means simple. Chalcopyrite is not of much higher specific gravity than siderite, so that water-concentration would not be easy. Moreover, with so much pyrite in the ore, a concentrate high in copper cannot be obtained. It is doubtful whether the Minerals Separation, Ltd., would care for the ore. An alkaline circuit would be necessary, and the low grade of the ore and its limited extent would not appeal to their engineers. Dr. Garbe recommends roasting, leaching, and electrolytic treatment, but his statement is sketchy and lacking in detail. Moreover, it is to be questioned whether ore containing so much carbonate and oxide attackable by acid can be profitably treated by acid-leaching.

It is always a thankless task for a mining engineer to write a condemnatory report on a property, and much more so when previous reports made by other parties have been favourable. It is also unpleasant for a technical journal to join in a discussion of the situation which so arises. We should not have referred to the subject but for the fact that preliminary notices foreshadowing a public issue of shares had made their appearance in the financial Press. The directors now recognize that their first expert adviser was mistaken, to begin with, in his interpretation of the reports of the 'seventies, and that after the workings were unwatered he allowed his enthusiasm to get the better of his judgment when examining the pyritic siderite. The directors immediately abandoned the idea of appealing to the public for working capital, and they and their friends have footed the bill for the expenditure incurred.

REVIEW OF MINING

Introduction.—Though business throughout the country remains depressed, signs of improved conditions are being seen here and there. The Government has at last become aware of the fact that the extravagance of the spending departments is leading the country into debt, and that excessive taxation is killing enterprise. The cost of living and the level of wages are gradually falling. The prices of coal and iron are relaxing somewhat. The only unpleasant factor of the situation is the continued inability of the coal miners to grasp the position. They still seem to consider themselves privileged persons, outside the influence of economic laws.

Transvaal.—The Government has now taken a hand in trying to solve the labour question at the mines, and both General Smuts and Mr. Malan, Minister of Mines, have discussed the matter with the Miners' Union. The prospects of a recovery in dollar exchange and the concurrent disappearance of the gold premium is the cause of the Government taking this step. Certain proposals, details of which are not yet to hand, were put before the Union, intended for the purpose of increasing the amount of work done by the natives. As these were taken to represent the thin end of the wedge in the matter of removing the colour bar, and the consequent diminution in the white force, the Unions was dead against them, and the secretary said that if the proposals were persisted in the whole of the white miners in South Africa would strike within 48 hours.

Of the quarterly reports issued by Rand mining companies covering the period to the end of September, perhaps those of New Modderfontein and City Deep are the most interesting. As compared with the previous quarter, the cost per ton milled at New Modderfontein was 1s. 7d. less, and of 3,830 ft. of new development on the reef 2,750 ft. was payable, averaging 37·4 dwt. over 19 inches. At City Deep 1,080 ft. of new development on the Leader averaged 28·5 dwt. over 25·9 inches. The profit for the quarter was £210,994, which constitutes a record for this company.

Some months ago we mentioned that Cornish miners now out of work did not care to go to the Rand. One reason for not wanting to go there arises out of the present Phthisis law, which provides that applicants for work must satisfy the Medical Bureau that they are not suffering from any disease of the respiratory organs. It is clear that a Cornish miner is not inclined to travel to Johannesburg for medical examination, for, if rejected, he would have to bear the expense of a futile double journey. The Minister of Mines has now decided to allow a preliminary examination in England, but as the result of such examination is not to be considered final, the position is not greatly relieved. Obviously some further concession will have to be made if Cornish miners are to be attracted to the Rand.

South-West Africa.—The outputs of the Otavi mines at Tsumeb are being reported once more. During the six months to the end of September the shipments were 19,000 tons of ore, 830 tons of copper matte, and 150 tons of metallic lead.

Rhodesia.—The output of gold in Southern Rhodesia during September was returned at 52,436 oz., as compared with 53,200 oz. in August and 45,471 oz. in September, 1920. Other outputs for the month were: Silver, 12,977 oz.; coal, 54,504 tons; copper, 262 tons; asbestos, 588 tons; arsenic, 18 tons; mica, 4 tons. No diamonds or chrome ore were reported.

The Gold Fields Rhodesian Development Co. has made a profit of £114,064 for the year ended May 31 last, and has distributed £125,710, the dividend being at the rate of 10%. Under present conditions this result is distinctly satisfactory. The company's principal mining interests are in the Shamva, Falcon, Asp, and Planet-Arcturus gold mines, and in the Rhodesian and General Asbestos, Rhodesian King Asbestos, and the Standard Arsenic properties.

The Cam & Motor Mining Company has issued cable reports relating to rich discoveries on the 11th level. For 135 ft. on the south drift the average assay-value was 210s. over 55 inches, or, omitting the rich patches, 50s. over the same average width. It will be remembered that this company recently resumed operations after a spell of development and a rearrangement of treatment plant. The returns for September show 13,900 tons of ore treated for a yield of 4,771 oz. of gold. The par value of the gold is given at £20,233, and the premium obtainable is estimated at £5,500.

The working cost, including development redemption, was £10,241, and the royalties absorbed £1,286, leaving a profit of £2,260. It will be seen that the profit was about equal to the premium.

It will be remembered that the Jumbo company acquired a new property a year or more ago, known as the Tip Top. Milling commenced in January of this year, and until June 30, the date of the end of the company's financial year, 7,489 tons of ore was treated, yielding 2,628 oz. of gold, which sold for £13,801, including premium. The directors report that the working cost is less than expected, and that development results warrant further sinking. The company has obtained options on the Defiance claims to the west, and prospecting is now in hand.

Nigeria.—The position of the tin-mining industry continues to be very unfavourable and concentrates are accumulating in many quarters. For instance, the Keffi Consolidated reports that it has 200 tons of concentrates on hand in Nigeria. The question is often discussed by the various companies whether it would not be politic to curtail the output substantially.

With regard to gold mining in Nigeria, to which reference was made last month, the Naraguta company has issued an official statement announcing the early departure of Mr. Clyde Allan to Nigeria, where he will develop the gold lodes recently discovered at Birnin Gwari. At this juncture it is of interest to quote from Mr. Allan's report written in April last. The prospecting was originally commenced on alluvial ground, and by systematic loaming a lode was discovered. This, however, proved to be too low in content to warrant prospecting. Further work to the north was rewarded by better results. Good loams were got about ¼ mile to the north and a costeen at a depth of 6 ft. below the surface disclosed some good grade ore. A shaft, known as the A shaft, was sunk to 50 ft. to water level, and a cross-cut east cut the shoot, which had dipped out of the shaft at 35 ft. This cross-cut proved the ore-body at this point to be 12 ft. wide and ranging in value from 3 dwt. to 10 oz. per ton, the values being much higher than near the surface. An attempt was made to sink A shaft below water, but at 60 ft., or 12 ft. below water level, the water became too strong for the windlass to cope with it. A sample obtained at this depth showed 30 dwt. values; the corresponding section of the lode at 50 ft. assayed 14 dwt. Although the rich shoot at water level is not very long, there is evidence that it will lengthen as it goes down. The ore-body has no defined walls. It has been traced by loaming for a distance of 3 miles. The installation of a pump is necessary to prove the lode below water level. The crushing plant, to which reference was made last month, consists of a three-stamp mill.

Mr. Clyde Allan's discoveries have served to draw attention to the auriferous belts of Kano, Birnin Gwari, Ilorin, and other places in Nigeria, and we understand that several prospecting parties are being organized by other companies, in particular by companies hitherto associated with Australian mining. The fact that Mr. Allan conducted his prospecting for lodes by "loaming" shows that he is an Australian mining engineer.

Australia.—Labour still blocks the way to a resumption of operations at Mount Morgan. Last month the directors applied to the Arbitration Court for a new scale of wages 20% lower than those now ruling. The Court granted this application, subject to a small government subsidy for the men. The local branch of the Australian Workers' Union has, however, refused to allow the men to resume work on these reduced wages.

The ore reserves at the Kalgurli mine being exhausted, the assets are being realized, and notice has been given for the liquidation of the company. The surface plant is being bought by Oroya Links for £20,000. This latter company has very large reserves of ore that are unpayable with its present plant, but it is calculated that, by working on a larger and more effective scale by the addition of the Kalgurli plant, satisfactory profits can be made.

We hear with regret of the final closing of the Mount Boppy mine, the chief gold producer in New South Wales, and situated not far from the Great Cobar copper mine, now also closed. The mine was acquired by Messrs. John Taylor & Sons, who floated a company to work it in 1899. The total gold output has been £1,812,699, and the dividends £446,058. Operations have been impeded from time to time during recent years alternately by floods and prolonged droughts. Finally the developments ceased to disclose ore either longitudinally, laterally, or in depth. During the past year the mine was kept going by selective mining of the reserves. The payable portions are now exhausted, and operations have ceased. The company owns half a million tons of

sand and slime residues, and these are to be worked on royalty terms conjointly with a local company. The directors are in negotiation for the acquirement of another property, which is sufficiently near to warrant the transference of the plant and machinery. As the examination of the property is not yet concluded, nor are the terms of purchase settled, no details are as yet available for publication.

It has been decided that some of the accumulated zinc concentrates purchased by the British Government under that unfortunate ten-years' contract are to be shipped to England, and offered for sale here through the British Metal Corporation. It is believed that the Government will be prepared to take any price within reason, so that the public expenditure may be recouped to some extent, and also that the zinc smelters shall be able to operate at a profit and provide work for the men at present unemployed. The zinc mine owners in Great Britain view this policy with unabated dismay, but are hoping that the Government will be able to do something which will bring employment to the home zinc miners.

Amalgamated Zinc (De Bavay's) reports by cable that, during the half year ended June 30, 128,646 tons of zinc material was treated for a production of 37,201 tons of zinc concentrates and 815 tons of lead concentrates. The accounts did not show any substantial profit, but the directors have decided to distribute a dividend of 1s. per 20s. share out of the equalization reserve.

In a recent issue it was announced that the Mount Bischoff tin mines in Tasmania had been closed, though no definite reason was assigned in the cable message. By mail we learn that the stoppage was caused by exceptionally severe snowstorms which continued for over a week. Open-cut working and transport were rendered impossible, the roof of the new mill buildings gave way, and the electric light and power cables were broken. It is feared that many prospectors in this region will have lost their lives from exposure, and there is also some anxiety as to the fate of the osmiridium washers.

Reports have been received in this country of an oil enterprise on the Fitzgerald River, near Bremer Bay, West Australia. There appears to have been considerable excitement locally, and Government geologists were sent to examine. Competent mining men, however, declined to believe in the discovery, even in spite of the alleged samples. It was ultimately found to be a case of salting of a particularly clumsy character.

India.—Shares in a new company called the Anglo-Burma Oil Co., Ltd., have been offered to the public this month. The company is to acquire the shares of the New Indian Petroleum Co., Ltd., which controls certain oil-mining rights at Singu, Burma; it acquires also some oil lands in Trinidad. In both cases the properties appear to be only unproved prospects. The financial arrangements are complicated, and the method of issuing the shares is not an attractive one.

A company called the United Steel Corporation of India, Ltd., has been formed in India by Bird & Co., of Calcutta, in association with Cammell, Laird & Co., of Sheffield. The company will take over collieries and coalfields in Bihar and Orissa, controlled by Bird & Co., and will develop iron ore deposits. Works are to be built with a capacity of 600,000 tons of pig iron per year, and steel works and rolling mills are to be erected.

Malaya. — It will be remembered that eighteen months ago the Ipoh Tin Dredging Company issued further capital for the purpose of extending operations and constructing two new dredges. Unfortunately the slump in tin and the impossibility of selling the whole of the new shares have placed the company in a position of financial difficulty, and the company has been unable to complete payment for the dredges. The company has this month made an agreement with F.M.S. Timah, Ltd., which controls the neighbouring Kamunting Tin Dredging Co., whereby the latter will acquire one of the new dredges and the land which it is intended to work.

Siam.—The Renong Tin Dredging Company made only a small profit, £4,028, for the year ended June 30 last, just sufficient to pay the dividend on the preference shares. The output of the two dredges at Renong was 756 tons, as compared with 433 tons the year before, but any benefit derivable from this big increase was nullified by the drop in the price of tin. There was also additional expenditure on a dam built for the purpose of diverting the river channel so as to enable one of the dredges to work the upper portion of the valley. The third dredge has been removed to the Rasa property, in the State of Selangor, acquired early last year. It started operations on March 17, and until June 30 had extracted 90¼ tons of concentrate

[illegible], which corresponds to a yield of [illegible] per yard.

Cornwall.—The directors of East Pool & Agar have approved the plans of the engineers for the sinking of the new shaft, and arrangements are already in hand for a commencement of operations. This work will relieve the position as regards unemployment in Cornwall to a certain extent, and the fact that no tin will be produced for some time is all to the benefit of the tin market. The decision to start the shaft apparently indicates that the proposals to join forces with South Crofty have ended in nothing.

The last meeting of the Levant Mining Co., the old cost-book company, was held last month, when the final disposition of the funds was arranged. The property now belongs to the new company, the Levant Tin Mines, Ltd., formed in February of last year. When the new company was formed the intention was for Geevor Tin Mines, Ltd., to provide working capital so that Levant and Geevor could be worked conjointly. Owing to the slump in tin, Geevor has not been able to provide the funds, so Levant continues independently, under the direction of Colonel F. F. Oats. He has bought the stamp-mill from Tincroft, and will start working ores accumulated at the surface during long years. With the income thus derived he intends continuing development between the 120 and 170 fm. levels.

The plight of Cornish mining was the subject of a question in Parliament last month, put by Sir Edward Nicholl. The Minister of Mines was not sympathetic at the time, but it is understood that he has sent representatives to Cornwall to investigate. There have been plenty of investigations, committees, and reports already, but nothing has come of them, and the only recommendation likely to be made by the present investigators, namely, an amalgamation of the mines, is not likely to be acceptable locally.

North Wales.—The Aber-Llyn company, which was formed to work a zinc-lead mine near Bettws-y-Coed, has now given up all hope of working this property at a profit under present conditions. The company also tried a china-clay property in Brittany, but soon found out that there was not sufficient material of satisfactory grade. Attention is now being turned to two groups of old gold mines, in Rhodesia and Portuguese Zambesia respectively. The former are the Killarney and Hibernia mines, and the latter are known as the Machinga and Mudzi River properties. Mr. Stephen J. Lett is to go out to make investigations.

Canada.—A cable has been received to the effect that violent rainfall (or cloud burst) has devastated the coastal region north of Vancouver. Several towns were overwhelmed by torrents of water, and in particular Britannia Beach suffered in tragic manner, fully fifty houses being carried away and many people drowned. The concentrating plant of the Britannia Mining and Smelting Company, which owns the big low-grade copper mine behind, was built at Britannia Beach, but it was burnt down in March last. Details are awaited by mail of this further disaster.

United States.—The recent policy among the American oil magnates of squeezing down production by lowering the prices to an unnaturally low level has had serious effects on the Anglo-United Oilfields, Ltd. This company was formed in 1919 to acquire oil lands in the Dallas field, Wyoming, and its development work and its contracts for the sale of its oil appeared to be perfectly satisfactory. New shares were created a year ago for the extension of the scale of operations. The depression of the price for the crude oil to the ridiculous figure of 28½ cents per barrel made it quite impossible for the company to meet expenses, let alone make a profit. At this juncture the underwriter of the new shares failed to carry out his contract, and about the same time also certain creditors who had advanced money for the purchase of the pipe-line pressed for repayment. In order to save the company it has become necessary to reconstruct and raise further funds. The price obtainable for crude oil has recently recovered, and Mr. Campbell M. Hunter, the company's technical adviser, is of opinion that operating expenses can now be met.

Bolivia.—Last month we quoted the financial results of the Compagnie Aramayo de Mines en Bolivie for the year 1920. The chairman, in his speech at the meeting of shareholders, held at the new headquarters, Geneva, reported that during the year 2,011 tons of tin concentrate was produced and 973,038 oz. of silver. There was no production of wolfram concentrate, and as usual no figures were given for the output of bismuth. He also mentioned that at the Chorolque mine, which was previously reported to be nearing exhaustion, new orebodies have been found.

VENTILATION AND WORKING EFFICIENCY

By BERNARD W. HOLMAN, O.B.E., A.R.S.M., Assoc.Inst.M.M., F.C.S.
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The author discusses the modern principles of ventilation and working conditions as applied to deep and hot mines.

The Human Machine.—In the case of a miner working underground what the employer pays for chiefly is work done. In the simplest case, that of a miner hewing coal in a colliery, or drilling holes in rock by hand in a metal mine, this work done is chiefly mechanical work. It is mechanical work which, actually, a machine could do and which can be measured as foot-pounds as the result of energy expended. Moreover, the miner's body in performing the work under such circumstances expends a given amount of chemical energy by converting it into heat and kinetic (motion) energy, just as a steam plant or an oil engine does when it performs work, although in the case of the human being the change is more truly a biochemic thermogenesis, that is, it does not conform to the Carnot cycle.

In a cool mine, as the efficiency of the human body is good, its employment in place of machinery, where either is applicable, is determined chiefly by the usual factors of first cost (housing and supply), cost of fuel and lubricants (food and drink), running costs (wages), and reliability (health conditions and strike frequency). But in deep and hot mines the question of actual efficiency becomes of paramount importance, because, like, say, a gas engine, the human body will only work between certain temperatures.

As water-jacketing is not practicable in the case of the miner, we have to confine our attention to air cooling. Air cooling can only be external, and the air must be used at low velocities because of the question of comfort; therefore, it can be seen at once that the upper temperature limit for efficient work must be very low. Unfortunately, this upper temperature limit is still further reduced by the complex method of burning (oxidizing) its fuel (tissues) employed by the human body.

Instead of completely burning a single portion of fuel at a time, as does an oil engine, the body partially oxidizes minute portions of a large number of tissues at the same time by means of the well-known reversible reaction: Haemoglobin + Oxygen $\leftrightarrows$ Oxyhaemoglobin.

Under the conditions of concentration and colloid solution existing in the human body, this reaction cannot take place above 130° F., else cessation (death from heart stroke) occurs.

Moreover, the mechanism for the change of heat into work is controlled by reactions in the brain (causing nervous stimulus of the respiratory centre) instead of by a metal governor. These reactions are still more subject to derangement by temperature rise (nervous fatigue, and, at higher temperatures, fever and delirium) than are those in the blood.

Hence it comes about that accurate temperature control of the body itself is absolutely essential for work even at normal temperatures. Nature has provided for this by the provision of an elaborate system of glands for secreting on the surface of the body moisture which, on evaporation, produces a very considerable cooling effect owing to the high latent heat of vaporization of moisture. Without evaporation but little cooling effect is produced by perspiration.

The warmer the surrounding air the more of this water must be produced and evaporated in order to maintain the body at a working temperature by perspiration, and the more rapidly must the blood be pumped to the cooled surface of the body. Hence the warmer the atmosphere the greater is the quantity of work done in merely keeping the body cool. Other secondary causes increase this additional work even more, although, of course, conduction and radiation also play their part in the cooling of the body.

Still saturated air at the same temperature as the body produces no cooling effect whatever, but still dry air, owing to the motion of the body in work, might produce an adequate cooling effect by evaporation alone, because naturally the dry air could take up moisture and thereby cause evaporation of the perspiration. Thus it is seen why such great importance is attached to the humidity of the air in a working place, sometimes rather to the neglect of other factors.

On the other hand, moving saturated air, so long as it was at a lower temperature than the body, would produce a cooling effect by

conduction, and, if a sufficient quantity passed over the body, an adequate cooling effect would be produced with saturated air by conduction alone. Hence the importance of the velocity of an air current as well as its humidity when considering its cooling effect. This has no direct connexion with the velocity necessary to supply an adequate quantity of fresh air for breathing purposes. Of course, within limits, the lower the temperature the greater the cooling effect for a given velocity, particularly if the air is not saturated. The effect of velocity in accelerating evaporation is then of prime importance. In fact, in practice both velocity and low humidity are employed wherever possible.

In the study of hygienic ventilation, of the three factors, humidity, velocity, and temperature, most attention was devoted to humidity, but in metal mine ventilation, where the laying of dust may necessitate a humid atmosphere, increasing attention is now being devoted to the effects of velocity and temperature on the actual rate of cooling of the body surface and to determine what conditions of humidity and velocity will give a healthy atmosphere even when the temperature is high.

The application of these results in practice is complicated by the fact that although two men may be equally cooled their capacity for work is not the same. In a hot healthy atmosphere the sweat glands of one man may act almost automatically and his heart do comparatively little extra work in stimulating increased subcutaneous circulation of the blood, while, under the same conditions, another man may feel so exhausted that he cannot work at all. Such a mathematically difficult matter as a stone or two of fat on an individual would quite invalidate any *a priori* calculations as to his thermodynamic efficiency on a given load. Hence it is readily seen that it is exceedingly difficult to calculate or measure the actual amount of work done in cooling the body under different conditions, although the nett output of work can, of course, be observed.

THE ERGOMETER.—Of late years attention has been directed especially to the actual task of devising means of measuring the output of mechanical work of different individuals as compared with their fuel consumption. For measuring such output of mechanical work various forms of specially adapted dynamometers have been devised, called "Ergometers," but for measuring the corresponding fuel consumption no cheap and handy apparatus has yet been evolved. The simple method of subtracting the unconsumed fuel rejected by the system from the food taken into it gives no useful result owing to the long and indeterminate time factor involved in the building up and oxidizing of individual tissues. Efficiency determinations on this basis would have to be of several days' duration; this and the difficulty of allowing for periods of sleep render the method scientifically and commercially useless in mining practice.

Another simple method is to burn in a bomb calorimeter a proportional part of the day's rations of a number of men, and to calculate the B.T.U. supplied and compare the result with, for instance, the number of inches drilled by hand in a day on the mine by the men who ate the food. Such results are too approximate to apply to the testing of individuals, and are, therefore, more of a check on the food than on the work.

The only method of estimating individual fuel consumption that has met with general success is based on the measurement of the amount of CO_2 expired by such an apparatus as is shown in Fig. 1, for example. Like flue-gas analysis its results are more relative than absolute. Also for accurate work apparatus which is neither simple, cheap, nor easy to manipulate has to be employed to determine the total amounts of gases involved in an experiment. Now that results of definite value have been obtained a simplification and cheapening of the apparatus is to be hoped for. A considerable advance in the ease and accuracy of determinations has been achieved by Professor Langlois for the French Department of War, but no cheapening.

With the human machine the amount of fuel burnt cannot be calculated directly from the amount of CO_2 produced, because other fuels besides carbon are consumed. A factor called the R.Q. (Respiratory Quotient), the ratio by volume of the oxygen consumed to the CO_2 exhaled, has to be used. The reason for this is that not one but three kinds of fuel are oxidized simultaneously in the human machine, namely carbohydrates, fats, and proteins. Each of these takes a different proportion of oxygen for its combustion.

For all carbohydrates the R.Q. is 1, according to the equation :—

$$C_6H_{12}O_6 + 6O_2 = 6CO_2 + 6H_2O$$

That is to say, when carbohydrates are

burnt the volume of carbon dioxide produced is identical with the volume of oxygen consumed.

For proteins and fats the R.Q. is naturally not so high, because part of the hydrogen in these compounds is available for fuel, and therefore uses up oxygen in forming water. Professor Krogh gives the average R.Q. for protein as 0·80, and for human fat as 0·71. The composition of the latter is taken as 76·5% carbon, 12% hydrogen, and 11·5% oxygen.

Alcohol contains still more available hydrogen than fat, and, therefore, has a still lower R.Q., namely 0·66, according to the equation :—

$$C_2H_5OH + 3O_2 = 2CO_2 + 3H_2O$$

If it were not for the unpleasant results of drinking strong beer (as one's sole food) and its only partial assimilation, perhaps only due to lack of sufficient practice, it would be the most efficient of all foods for the miner. Bacon and ham have excellent food values ; also pigs have a more efficient basal metabolism than men, and can feed on the waste products from the manufacture of beer. Therefore, as a mining engineer, one is tempted to desire a thermo-dynamic miner-beer-pig cycle more efficient than any Diesel-Still engine. Unfortunately, one's digestion will not stand it, and in our greatest mining country prohibition would not allow it.

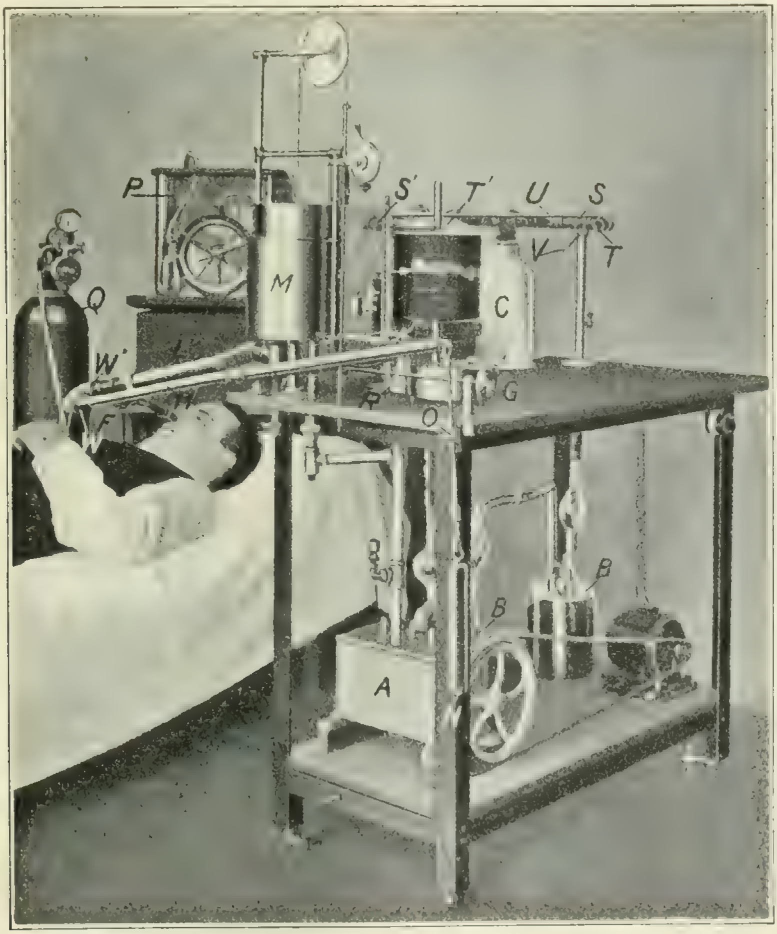


Fig. 1.—Benedict's Respiration Apparatus.

The figures given above are for normal temperatures. The R.Q. rises with increasing temperature and also varies with the load (amount of work done). The following table shows clearly how the R.Q. affects the calculation of the heat produced and the food consumed. The Respiratory Quotient is,

of volumes, is also equal to the ratio of the weight of oxygen consumed to the weight of carbon dioxide exhaled.

Per Litre of Oxygen.

R.Q.	Glycogen Catabolized, grammes.	Fat Catabolized, grammes.	Heat Produced, calories.
0·71	0·0000	0·5027	4·795
0·75	0·1543	0·4384	4·829
0·80	0·3650	0·3507	4·875
0·85	0·5756	0·2630	4·921
0·90	0·7861	0·1753	4·967
0·95	0·9966	0·0877	5·012
1·00	1·2071	0·0000	5·058

The following figures are also useful in such calculations :—

1 litre of oxygen at normal temperature and pressure (N.T.P.) weighs 1·429 grammes.

1 litre of carbon dioxide at N.T.P. weighs 1·965 grammes.

1 litre of nitrogen at N.T.P. weighs 1·255 grammes.

1 litre is equal to 0·0353 cubic feet.

1 cubic foot is equal to 28·32 litres.

1 ounce = 28·35 grammes. 1 gramme = 0·035 oz.

From the above it appears that if fat only were consumed and 45 litres per hour of carbon dioxide were produced, a loss of 32 grammes ($1\frac{1}{8}$ oz.) of fat per hour would result, and a heat production of above five calories per minute might be expected. This would be equivalent theoretically to $\frac{1}{5}$ horse-power.

Dr. Leonard Hill mentions as large an amount of oxygen used per minute as 3·361 litres when bathing in rough cold sea. Taking this as approximately equivalent to 3 litres per minute at N.T.P., with an R.Q. of 0·80, from the above table the heat produced would be 14·6 calories or 0·58 h.p. With 33% efficiency (see later) this would equal about $\frac{1}{5}$ h.p. actually exerted in mechanical effort. This is interestingly near to the old figure of five men to one horse-power. The weight of carbohydrate consumed per hour would be 66 grammes and of fat 63 grammes, a total loss of weight of over $\frac{1}{4}$ lb. per hour. So high a figure would only apply to periods of exertion and would be far less with the same individual sleeping. For the resting body the functional activities amount to only 25% of the standard metabolism (Krogh) ; but a man in perfect training may for short periods of great exertion have a respiratory metabolism twenty times the minimum (Krogh).

In Great Britain many measurements of the output of work have been made for the Mine Rescue Apparatus Research Committee. In these the "Cycle Ergometer" of Professor Martin, F.R.S., was used (Fig. 2). It is fully described in an appendix to their Second Report. It consists of a cycle frame and seat mounted on a stand with a heavy fly-wheel substituted for the back wheel of the bicycle. Round the fly-wheel passes a brake strap, the ends of which are connected to spring balances in the ordinary way so as to constitute a dynamometer brake.

Mr. H. F. Bulman recommends a gear of $3\frac{1}{4}$ to 1 with a fly-wheel 2 ft. in diameter, so that fifty revolutions a minute of the pedals is equivalent to 3,500 ft.-lb., when the difference of tension on the springs is 4 lb. With a dry belt various ranges of load can be obtained by slacking or tightening the belt. The oxygen consumed may be measured through a valve if compressed oxygen is being used on the tests, while the expired air is collected in a bellows-shaped bag of convenient form and supplied with a suitable tube, mouthpiece, and nose clip.

Two other forms of ergometer have been devised and used by Dr. A. J. Orenstein, and were fully described by him in his recent paper (March) before the Chemical, Metallurgical, and Mining Society of South Africa. One of these is a hand-operated dynamometer brake which was calibrated "by substituting a narrow wooden pulley for the driving crank, and of the same radius, and driving the machine by pulling a cord off this driving pulley, the pull being read on a spring balance." This machine, which Dr. Orenstein calls his "rotary dynamometer" (Fig. 3), is very simple to construct and use, but as it is operated by the hand and not by the feet it is not easy to carry out respiration tests simultaneously. Like the Martin ergometer it measures work of a purely unskilled nature and does not imitate closely any operation carried out in mining.

To meet this objection, Dr. Orenstein designed his cylinder dynamometer which actually registers the number and force of the hammer blows given to a piece of drill steel bearing on a diaphragm in a closed cylinder containing boiled water (Fig. 4). The variations in pressure in the cylinder are recorded on an indicator diagram by an ordinary indicator as used in steam-engine practice.

This machine has to be of very robust construction, which gives it excessive weight.

It was also found to be particularly liable to various errors due to " condition of jointing rings, slight obstructions in connecting pipe, presence of small bubbles of air, friction in the indicator piston, etc." This made frequent calibration necessary, and often caused the loss of a day's work. Nevertheless, many successful tests were carried out, the results of which are given in the exceedingly useful paper mentioned above.

capacity to withstand fatigue, vary greatly in different individuals, and, what is of first-rate practical importance, show up in tests of this nature. Hence these tests give us an insight into the nature and effects of fatigue which are shown to be very similar to those of overload on an oil-engine. A fairly heavy task may be performed for a short time without causing any fatigue, but if it be carried on too long a definite state of exhaustion

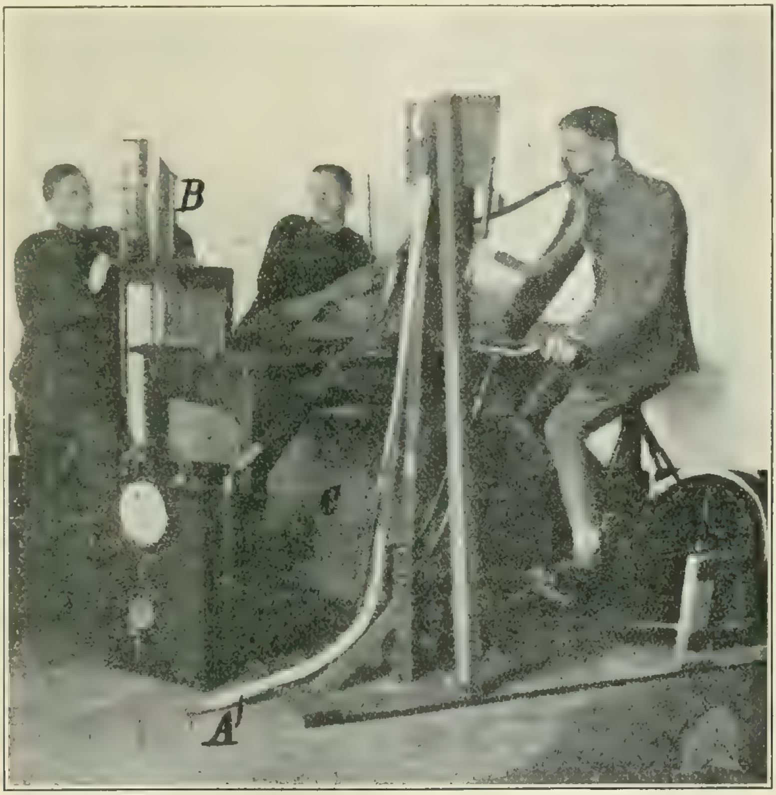


FIG. 2. MARTIN'S CYCLE ERGOMETER.

occurs, and exertion has to be stopped until cooling and re-cleaning has taken place. As is well known a heavy task which would utterly exhaust one man is easily performed by another who has practised it often. This is one cause of the varying results obtained by independent workers, but on the same man the improvement due to training can be definitely measured. Therefore, having found a man to be of good stamina and in good training, one can proceed to test the effect of physical conditions such as humidity and velocity of air on his working efficiency.

EFFICIENCY AND THE INDIVIDUAL.—One of the most striking things about the great mass of work performed on this subject of the efficiency of the human machine is the very different results obtained by different observers. The results recorded (Krogh) by admittedly first-class observers using normal subjects vary from 2·8 cc. of oxygen absorbed per kilogram minute (0·8 calories) to 5·5 cc. of oxygen absorbed per kilogram minute (1·6 calories), but these results have often been obtained by experiments on abnormal subjects, for instance, very ancient paupers.

Briefly, the degree of training, or capacity for exertion, and the amount of stamina, or

EFFICIENCY AND PHYSICAL CONDITIONS.—Adequate oxygen and absence of poisonous

[illegible] necessities for efficient work, and are readily tested for by chemical means, but fatigue and correct body temperature are less readily estimated. The amount of work which produces fatigue is generally left to individual judgment, tempered by a general bonus on extra footage or tonnage (unless the Unions decree otherwise), but correct body temperature is a matter of racial peculiarity tempered by ventilation. There is a fifth physical condition necessary for maximum efficiency, and that is optimum effort. The optimum effort is not necessarily the greatest individual exertion, but is the best distributed effort throughout the shift which will produce the maximum output without producing fatigue. This can only be determined by actual tests. The quantitative study of this question as applied to metal mining is in progress ; for instance, a study is being made of the effect of short and long rests, frequent and infrequent, for hand-drillers.

Optimum effort, like fatigue and correct temperature, depends greatly on the purity, dryness, and velocity of the air, in which the individuals work ; hence it comes about that ventilation is now required not only to supply oxygen and to sweep out noxious gases, but also to cool the workers in the manner which causes their work to produce least fatigue in them. (See tests on optimum speed of walking, p. 17 of the second report on Mine Rescue Apparatus.) Hence the humidity and velocity of the current receive as much attention now in some mines as its quantity and purity, when considering the question of whether or not the ventilation is adequate.

ADEQUATE VENTILATION.—The chemical theory was the earliest accepted explanation of the injurious effects of inadequate ventilation. It was based on the idea that " the evil smell of unclean and badly ventilated places was evidence of a ' vitiated effluvia ' or volatile poison added to the atmosphere by exhaled or expired air," and also that the oxygen content of the air became unduly diminished.

As exhaled air contains much carbon dioxide, the excess of CO_2 found in a badly ventilated place was taken to be a reliable indication of the amount of this poison present. Several Acts and Regulations based on this idea allowed an excess of CO_2 only a few parts per 10,000. Many hygienists supposed CO_2 itself to be a poison, particularly as a large excess of it, such as found in some natural caverns, will cause death. That this latter was a popular delusion was demonstrated long ago by the simple experiment of breathing without any ill effects air with 1% of pure CO_2 added to it. Any sincere investigator can satisfy himself that this is so in the congenial environment of a brewery, where the air often contains over 1% of CO_2. One per cent is, of course, many times the amount (4-10,000ths) fixed as the safe limit in some Acts. Even 3% can be breathed without any ill effect being noticed until muscular exertion is attempted. Then panting ensues, merely owing to the need for greater pulmonary ventilation with such air. Moreover, in man the blood keeps the pulmonary air constant at about 5% CO_2. Hence carbonic acid obviously cannot be a poison, and, of itself, cannot be a cause of the ill effects of bad ventilation.

It was also considered that air in poorly ventilated places became badly impoverished in oxygen, and that this impoverishment caused harmful physiological effects. That this impoverishment is great was directly disproved by analysis.

The diminution of oxygen in ill-ventilated places is exceedingly small, even in a bad stope or in the most crowded room ; it is seldom more than one per cent. Such a small reduction has no harmful effect. This is obvious when one considers that people live comfortably at altitudes where the amount (weight) of oxygen per cubic foot is only two-thirds of that which it is at sea-level. With such reductions of oxygen the pulmonary ventilation and the circulation are increased, the blood is thinner, and the proportion of acids to bases in the blood is altered to compensate for the lactic acid formed. Hence diminution of oxygen cannot be a cause of the ill effects of bad ventilation. This was very clearly demonstrated in one of Dr. Leonard Hill's experiments, where students were confined in an atmosphere of only 17% oxygen, so low that a match would not burn in it. No discomfort was felt so long as the air was kept moving by a fan, and the cooling of their bodies thus assured.

The main part of the chemical theory, the popular idea that exhaled air and stagnant perspiration contain a poison apart from infection, is very severely dealt with by Dr. Leonard Hill. He quotes the work of many experimenters to disprove it, and concludes by saying " there is no evidence worth anything at all as to the existence of

this poison." Certainly too many of these experiments seem to have been tried on animals. Even the Kenotoxin of Weichart was not tried on his neighbour.

Dr. Hill's own experiments on the effects of prolonged breathing of exhaled air were tried on guinea-pigs. Yet guinea-pigs are so different from human beings in their requirements that they can tolerate an extremely high saturation of CO, and in his experiments on them at the bottom of deep boxes they seemed to tolerate all the other conditions of bad ventilation, too.

As water infected with dead bacteria produces so many unpleasant effects it is not quite clear why air so infected should produce absolutely none at all. Shivering and headache are common symptoms of bad ventilation, and also accompany the injection of dead bacteria. Moreover, the quantities of substances required to produce biological effects are so very small that they might easily escape chemical analysis; for instance, one part of copper in 77 million of water is toxic to spirogyra in one minute.

Early medical writers who knew few theories, but had ample acquaintance with facts, believed that the "invariable result of the accumulation of breath and perspiration of human beings crowded together and neglecting personal cleanliness was to produce plague and fever." This seems a safer guide to practice than the idea that the cause of such ill effects are microbes which come from somewhere else, whether from

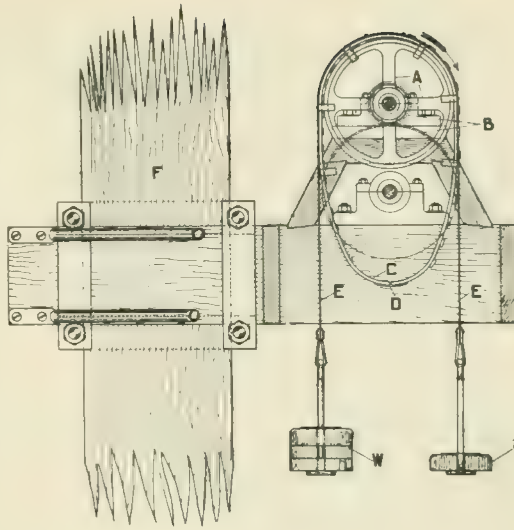


FIG. 3.—ORENSTEIN'S ROTARY ERGOMETER.

colloid solutions or from the survival of the fittest is not explained. One rather wonders whether a visit to a dead end in some metal mine where hand-drilling is being employed on a handsome bonus system, and the booster fan has temporarily broken down, would overpower one not used to such pungent "non-existence." The cause of the physical nausea produced in the visitor, if it is not chemical, might be radio-active; it certainly is not psychic. The remaining alternative is that it is physical. This is precisely the idea which now holds the field as the explanation

FIG. 4.—ORENSTEIN'S CYLINDER ERGOMETER.

of all the effects of bad ventilation, although the bacteriological effect of exhaled air is still adhered to by some. The chemical theory, so far as it concerns the poisonous nature of pure carbon dioxide, and so far as it concerns the harmful effect of any practicable diminution of oxygen, has been completely disproved, and it has been realized that the proper control of the body temperature is the important thing. Hence any definition of adequate ventilation which is based solely on percentages of carbon dioxide and oxygen in the air is not adequate and may be very misleading.

HUMIDITY THEORY. This idea of the physical nature of ventilation has been developed along two lines. Firstly, by those who considered the drying power (humidity) of the air as of most importance in cooling the body by promoting free perspiration, etc.; and secondly, by those who placed their faith more in the free circulation of the air, even though it was not very dry or very pure. The latter method is of most interest to metal miners, because they so often have to deal with saturated air (for dust) underground, and do not need large volumes except such as are adequate for cooling.

The use of hygrometers and anemometers and the application of the knowledge gained thereby to the ventilation of mines is being investigated very fully by the Committee on the Control of Atmospheric Conditions in Hot and Deep Mines, under Professor Sir John Cadman. This Committee has published three reports. (See Bibliography.) Dr. J. S. Haldane had also directed much work on these lines at the Doncaster Coal Owners' laboratory and elsewhere.

As has been pointed out already, proper sweating is a very effective method of cooling the body, because it makes full use of the latent heat of evaporation of the water. So long as the sweat can be produced and evaporated, the less saturated with moisture (lower in relative humidity) the air is at a given temperature, the less volume is required for a given amount of cooling. Therefore, for a given velocity and temperature the lower the humidity is the greater will be the cooling power of the ventilating current. It is for this reason that such great attention has been paid to the question of humidity in colliery practice. In British colliery practice for several generations ample ventilation has been necessary in order to sweep out from the workings all noxious and explosive gases. Hence the quantity, purity, and velocity of ventilating currents has received much study in England. Not only so, but owing to the very high geothermic gradient in this country (over 1°F. for every 70 ft., instead of for every 254 ft. as on the Rand) the question of the cooling capacity of ventilating currents also came early to the fore. There are now collieries working in England at a depth of 3,500 ft. where the rock temperature is about 100° F., a temperature which would not be reached on the Rand until a depth of nearly 9,000 ft. Thus it comes about that the study of artificial ventilation in mines has been left almost entirely to colliery engineers until quite recent years. It is only during the last ten years that artificial ventilation for metal mines was introduced at all generally in South Africa, and then it was chiefly in response to legislation. Natural ventilation had been found adequate for depths of over 2,000 ft. even where very many natives were employed. It may almost be said that it is only during the last five years that *copious artificial ventilation has become a necessity in many metal mines.* In such cases the chief object of artificial ventilation is generally to improve the physical comfort of the men, and is not the maintenance of the purity of the air. As huge volumes of air are not necessary for sweeping out natural gases from such mines, the obtaining of the optimum combination of humidity, velocity, and temperature is a matter of considerable importance. Theoretically each of these three factors can be varied independently to obtain a given cooling power, but unfortunately in many deep metal mines precautions have to be taken against dust. For this latter purpose the crude but safe expedient of spraying the workings liberally with water is generally adopted. This limits the metal mine in such cases to the use of air of nearly maximum humidity, while the colliery engineer is free to base his calculations on the dryness at surface of the air and to take precautions to prevent the unnecessary absorption of moisture by his ventilating current. It is owing to these facts that the wet and dry bulb thermometer has been employed so much by colliery engineers, to the exclusion of other methods of measuring cooling power, while the metal miner resorts to other means. For example, in Mr. Clifford's classical paper before the Institution of Mining and Metallurgy

(February, 1921), any full discussion of hygrometer and anemometer readings, together with all talk of grains of moisture per cubic foot of air and of moisture content charts are absent. The great accumulation of recorded practical experience and sound experiment by colliery engineers was of little value to him as far as it concerned the cooling power of ventilating currents. Nevertheless, the principles underlying the use of the hygrometer should be understood by all.

In the first report of the Committee on Hot and Deep Mines, the use of the wet and dry bulb thermometer as a hygrometer is very clearly explained as follows :—

The use of the wet and dry bulb thermometer rests on the fact that when there is a sufficient air-current to swamp the influence of radiation and conduction . . . a moist surface will assume . . . " a definite temperature between the air temperature and the dew point."[1] " When no other source of heat or cold is affecting the surface this intermediate temperature is known as the 'wet bulb' temperature, and is the temperature assumed by the bulb of a thermometer kept moist with water.' It is the minimum temperature to which a moist surface can be cooled by the air present at the given velocity.

The skin temperature of a perspiring man always lies between the body temperature and this "wet bulb" temperature. As long as a man is perspiring normally his skin temperature will approximate to the wet bulb temperature more closely the higher the velocity of the ventilating current. Increase of velocity, therefore, increases the cooling effect on the skin, but increase of humidity, shown by approximation of the wet bulb temperature to the dry bulb temperature, considerably reduces it until, when the air is saturated, one has to rely on velocity and difference of temperature alone for cooling power.

In still air Dr. Haldane found that 88° F. during rest and 78° during work with minimum clothing were the highest wet bulb temperatures a miner could stand in Cornwall without profuse sweating. (This was independent of separate observations of air temperature, absolute humidity, dew point, and velocity.) In *perfectly still air* Dr. Haldane found that this wet bulb temperature was all-important, and that even when the air current was too hot and warmed a man instead of cooling him this warming depended on the wet bulb temperature and not on the air temperature. In England the outdoor wet bulb shade temperature reached 70° F., but in moist tropical countries it reached 80° F., but with dry tropical heat it may be below 70°, although the shade temperature is 110° or more. Hence, again, we see the importance of low wet bulb temperature, and why in colliery practice so much attention has been devoted to keeping down the wet bulb temperature; also why the wet bulb temperature has been taken as a standard of comfort while the study of the effects of increasing the velocity of the air current has been neglected. In fact, one report of the Hot and Deep Mines Committee speaks of keeping the air in motion in all working places as " a subsidiary aim." When the metal miner has to deal with a hot deep mine it unfortunately has to be his chief aim.

In colliery practice, then, adequate ventilation can be defined by the precentage of foreign gases allowable in the air and by its wet bulb temperature. It is specially necessary to limit the maximum allowable hydrocarbons because of their explosive nature, and of CO because of its toxic effects, but in hot metal mines where the air is saturated such a definition is insufficient. Nevertheless, in both cases " the problem of underground temperature control seems to resolve itself into one of adequate ventilation."

Effect of Velocity.—How adequate ventilation can be defined independently of observations with a wet bulb thermometer in the case of mines with saturated air has been fully worked out and explained by Dr. Hill in his brilliant work the *Science of Ventilation*. This book (two volumes) is a summary of years of original work by the author and his associates, both on theory and on actual experiments. It leaves out some of the more abstruse theoretical considerations dealt with in the original papers, and evolves clearly the author's theory of the paramount influence of velocity on cooling effect. It also gives details of his final triumph, the production of a cheap and extremely simple instrument, the kata-thermometer, which measures directly the actual cooling power of a ventilating current in terms of calories, or of B.T.U.s,

[1] The temperature at which water begins to condense from air of a given moisture content is called its dew point.

per unit of area exposed. Based on such readings it is possible to give a simple definition of an adequate ventilation current in a manner which admits of fully saturated air or of high wet bulb temperatures quite inadmissible in still air, yet makes accurate allowance for the compensating effect of the velocity of the air.

This mode of definition rests on the theory that heat stagnation of the body is the prime cause of the discomforts (headache, sickness, faintness, etc.) resulting from bad ventilation and that movement of air is the surest preventive of such stagnation. Many experiments in support of this theory are given by Dr. Leonard Hill's report on "Ventilation and the Effect of Wind" (see Bibliography). One of the most important of these (p. 15) has been often quoted. It has been carried out by eight different investigators (four in England and four in Breslau). Seven or eight students were shut in an air-tight chamber of only three cubic metres capacity for half an hour. In this chamber the air could be moved by fans placed in the roof and the temperature and humidity could be varied as desired. The CO_2 was gradually increased to about 4%, and the oxygen lowered to about 19%, the air failing to support the combustion of a lighted match. The wet bulb temperature rose meanwhile to over 83° F. With the dry bulb it was a degree or two higher. The discomfort was considerable, pulse rate high, faces flushed and moist, but no headaches. Stirring up the same stale air by means of the fans gave immediate relief. The pulse rate was lowered from 97 per minute to 79, though no fresh air from outside was admitted. The air of the chamber breathed by other students outside caused no discomfort, whereas students inside breathing the outside air before the starting of the fan felt no relief. This experiment was a most astonishing refutation of very widely accepted views on ventilation. Such excess of CO_2, diminution of oxygen, and high wet bulb temperature were each supposed to cause the greatest discomfort. So they did until the fans were started up. In every one of the other similar experiments putting on the fans gave great relief. Moisture and warmth chiefly cause the discomfort and incapability for work associated with a so-called "vitiated atmosphere" when the air is still.

The first effect of heat stagnation is a rise of the skin temperature of the individual and an increase of pulse rate. Following this great extra work is thrown on the heart in its endeavour to keep the body cool by pumping as much blood as possible to the surface of the body. This extra amount of work may, of course, be so great as to cause death. American scientists have shown that the velocity of blood-flow in the arm may be increased eight-fold under such conditions, while in cool air it may fall to one-quarter the normal. Hence the great importance of the cooling effect of an air current is apparent, particularly when manual work is being considered and the heart is already working above normal load. Dr. Leonard Hill not only clearly demonstrated this, but he also showed that the ordinary thermometer, either wet or dry, does not show the cooling effect or heat loss, but only its own temperature.

While the thermometer is a static instrument the human body is a dynamic structure continually producing and losing heat. For example, on a calm or on a windy day the wet or dry bulb thermometer readings may be approximately the same. They may be most misleading as to the conduciveness of such conditions to efficient metabolism, and they give no indication of the bracing effects so familiar, for instance, on a breezy day at the seaside. A kata-thermometer, on the other hand, will give quite different readings under such sets of circumstances and will show clearly in which case the cooling power is greater and how great it is. The same applies to two ventilating currents of different humidity and velocity. Similarly in the case of men working in proximity to machinery, wet or dry bulb thermometer readings give no indication of the cooling effect due to the motion of the air around the machines. This may be quite appreciable and its effect is at once shown quantitatively by the kata-thermometer.

As already mentioned other experiments carried out by Dr. Leonard Hill showed that not only is the utility of wet and dry bulb readings often over-estimated, but that the old ideas about excess of CO_2 and deficiency of oxygen can be dismissed. The prime stimulant to bodily metabolism is cool skin temperature which is best obtained by the motion of air of suitable temperature and preferably, though not of necessity, fairly dry.

Evaporation from the respiratory tract also has a considerable cooling effect on the body when the air is dry, but is not, of course, much affected by external motion of the air.

It is also open to argument whether warm air in motion has the same effect on health as cool still air giving the same kata reading. The mysterious secondary effects of warming or cooling the body by radiation instead of by conduction are little understood. Some people certainly seem to derive increased energy from the sunshine without increased food, but sunshine does not concern the average miner, although one has heard of patent foods which claim to almost make the prospector live on sunshine, so small is the amount of the food supposed to be necessary for a meal. Perhaps such foods, together with the stimulus of "the joys of anticipation," turn the prospector into a species of solar heat engine instead! The effects on health of saturated air are merely mentioned to show that adequate ventilation is not nearly such a simple subject as it seems when one reads the works of any of our leading authorities, but not the work of his opponents.

When we come to the question of testing the degree of ventilation according to any predetermined standard of adequate ventilation we are on much firmer ground.

Testing Degree of Ventilation.—Although the chemical theory of ventilation is incorrect in so far as it concerns impoverishment of oxygen and the harmful effects of small excess of CO_2 above the normal amount found in our atmosphere (0·03% or three parts in 10,000), chemical tests are useful to indicate the degree of ventilation, particularly where CO may be generated by the use of large quantities of explosives. Carbon monoxide (white damp) is a very dangerous poison with a cumulative effect; 0·1% will quickly render a man incapable of walking, while 0·04% will produce the same result but more slowly. Chemical tests are still insisted on in many countries and are troublesome on metal mines where no chemist is employed. Carbon monoxide is particularly difficult to determine accurately. Vogel's blood test is often recommended but it is only approximate. It is hardly suitable for use in a mine. It depends on the simple fact that ordinary blood diluted with 200 times its volume of water gives a yellowish red solution which turns pink with CO. Any such pink solution obtained is compared with standard colour solutions made up from the blood of mice poisoned with CO. The colouration of palladium chloride by CO has been suggested, but it it unreliable, as other organic substances give the colours with this salt. The best method is a combination of the palladium chloride and iodine pentoxide methods. This gives accurate results but requires expensive apparatus and considerable analytical skill, and is therefore best not attempted on a small mine.

Carbon dioxide, on the other hand, can be accurately determined fairly readily on a mine. As big a sample as possible should be taken, its temperature and pressure, of course, being noted. Large glass bottles of known volume and a pair of bellows with a sufficient length of rubber tube to reach to the bottom of the bottles may be used. Rubber stoppers are required and particular care must be taken to keep the bottles dry and clean inside. A sample having been taken, a known volume of potassium hydrate solution is suitably introduced and the bottle well shaken, then washed out. The potassium carbonate formed is determined by titration with a standard solution of oxalic acid which shows the amount of free potassium hydrate left. Lime water may be used instead of caustic potash. The calcium carbonate is estimated by titrating back with oxalic acid, using phenol-phthalein as an indicator.

Humidity on a mine is never determined by analytical methods. Advantage is taken of published tables by which the humidity can be calculated from the observed difference in the temperature shown by an ordinary or dry bulb mercury thermometer, and by one whose bulb is surrounded by a piece of cotton or silk material which is kept moist. The dryer the air at a given temperature the more rapidly will moisture evaporate in it, because the greater will be the cooling effect of the air on the wet bulb thermometer. If the air were saturated with moisture there would be no evaporation from the moist material; the wet and dry bulb thermometers would therefore then give the same reading. A pair of thermometers arranged for the convenient taking of such readings is often called an hygrometer, or, more descriptively, "a wet and dry bulb thermometer."

The simplest forms of hygrometer are liable to errors due to the accelerating effect of air currents on evaporation. The best method of ensuring accurate readings is to ensure a rapid circulation of the air about the hygrometer. In practice it is simpler to circulate the instrument. A form of whirling hygrometer (Fig. 5 overleaf) is described thus in the third report of the Committee on Hot and Deep Mines. Two accurate mercury thermometers, from 6 to

6½ in. long, and with narrow long bulbs, are set in a wooden frame. They are fixed in grooves on cork pads with seccotine, and further secured by two metal bars set flush with the face of the frame. For most of the length of the thermometers the groove is cut right through the wood, so that the thermometers can be read by holding them against the light. An oval hole is cut in the frame of the bulb of the dry thermometer. A glass reservoir for water is fixed at the bottom of the frame. Above the neck of the reservoir the frame is cut away round the

Fig. 5.—Whirling Hygrometer.

bulb of the wet thermometer. This bulb is kept moist by a slip of muslin, which dips into the reservoir. At the top of the frame two pieces of metal are let into the side, and where they project at the top they are bored to take a spindle. The spindle and its wooden handle are secured by milled nuts, so that by a movement of the wrist a whirling motion can be given to the frame. The frame is carried in a tin case, which has a lid at itr top. The lid is secured over the spindle with the handle projecting at the side. The length from the spindle to the centre of the bulbs of the thermometers is about 6 in. The hygrometer may be easily whirled at 200 revolutions per minute, and the air then passes over the bulbs at the rate of over 600 ft. per minute. The prismatic type of thermometer has been found easy to read under all conditions, and from 40° to 110° F. has been found the most useful range for underground work. For surface readings thermometers reading to below freezing-point are, of course, necessary.

The above hygrometer is given as a very suitable one for mine work, though many other forms have been used. Some were shown by Dr. Ezer Griffiths at the Royal Society soiree in May this year, but did not appear suitable for mine work.

The method of expressing the results obtained has been the subject of some discussion. For general purposes of checking the ventilation of a mine it has been agreed to use grains of moisture per cubic foot rather than the wet bulb temperature, or grains per lb. for absolute or relative humidity or moisture. But in considering the variations in humidity throughout a mine "grains per cu. ft." is not a sufficient definition, for a given quantity of air naturally varies very greatly in temperature and pressure, and therefore in volume as it passes through a mine. For example, a cubic foot of air in a hot working place may be a very different amount from a cubic foot of air at the intake of the fan at the surface, or it may not be. This will depend on the compensating effects of the temperature and pressure to be considered, that is, on the depth of the mine, on the barometric pressure on the day of observation, and on the surface and underground temperatures, etc. Hence records of humidity as the actual moisture content in grains per foot in different places may, like some pleasures, have the doubtful virtue of reality, but otherwise be very unprofitable.

The following table from Dr. Hill's *Science of Ventilation* (part i, page 98) gives the maximum capacity of air at different temperatures for holding water vapour. It will be noted that this capacity increases rapidly with increase of temperature :—

Temperature of air Degrees F.	Maximum weight of water in grains per cubic foot.
30	1·94
40	2·85
50	4·08
60	5·75
70	7·98
80	10·9
90	14·7
100	19·7

"Relative humidity" is the term given to the ratio of the weight of water vapour contained in a given volume of air to the weight which this same volume would contain when fully saturated at the same temperature. It is expressed as a percentage. From the above table it will be seen that

when the relative humidity is low and the temperature warm the capacity of the air for water is great; therefore if in motion its effect on perspiration is great. It will be found that in all the best work humidity is expressed in grains of moisture per cubic foot reduced to normal temperature and pressure throughout, that is, moisture in a given mass of air, not a given volume, is recorded when results are plotted; thus a chart is obtained which shows the amount of moisture the air takes up in passing from place to place in the mines, and also gives the absolute humidity at any place (Fig. 6).

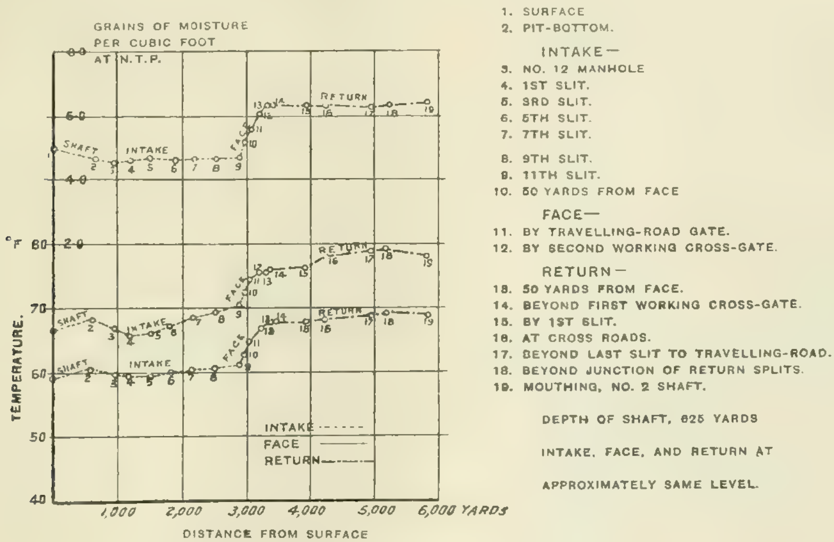


FIG. 6.—CURVES OF HUMIDITY ON A LEVEL

This is a special advantage because absolute humidity has a particular physiological significance. Such a chart combined with a temperature chart will show the loss of cooling power of the air as it travels through the workings provided the air is circulated through them at constant velocity. As this is never possible, and, moreover, as the velocity has such a preponderant influence on cooling power, its variations must be measured and allowed for.

Velocity is generally measured by means of some form of vane-driven anemometer, which has been previously calibrated in air currents of known velocities. These instruments are quite satisfactory for main levels, but give poor results with very low velocities, still worse ones with eddy currents, and none at all with such alternating air currents as traverse the skin of a working miner's body under his shirt or circulate about his bare arms as he works in a dead end where compressed air and not velocity may supply most of the all-important cooling effect. This latter class of case is of much practical importance, and together with the whole question of the effect of clothing can be dealt with but poorly by means of the hydrometer. Moreover, even in simple cases, it is often very difficult, particularly with slow air currents, to calculate the contributory cooling effect of velocity when given it and the hydrometer readings. Some writers appear to have applied the mediaeval principle of circumventing the pure concept. The effects of velocity have been ignored and humidity set up in its place as the all-important factor in cooling effect, although, to quote Mr. H. S. Ireland, " it is almost impossible in connexion with work in mines to overstate the importance of movement in the air."

All temptation for engineers to accept a simple faith in humidity has been taken away by the invention and perfection by Dr. Leonard Hill of that most convenient of instruments, the kata-thermometer. This invention is particularly opportune, coming as it does at the very time when the problem of deep metal mining is forcing itself upon the attention of many engineers.

The kata-thermometer is a special instrument which measures directly the actual combined cooling effect on a surface of an air-current of given velocity, temperature, and humidity; and also gives

the cooling effect due to radiation, convection, and evaporation, without the use of anemometers and wet and dry bulb thermometers or other hygrometers. It not only gives a single correctly integrated and perfectly intelligible figure, but it can be applied to eddy currents, low velocities, and even to still air. It is so compact that it can be readily carried in the pocket and

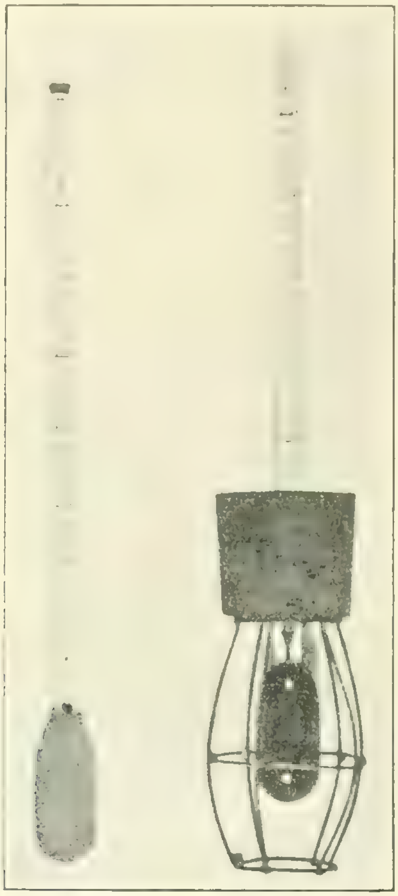


FIG. 7.—KATA-THERMOMETER.

can easily be used for taking observations next the skin underneath a man's clothing. It weighs less and costs less than any reliable anemometer or hygrometer, and, above all, is extremely simple to manipulate and easy to read in a poor light.

Also it is extremely simply constructed in a single piece, with no moving parts to get out of adjustment. In fact, it has been so perfected and so simplified that there almost appears to be nothing in it to write about. A glance at the history of other experimenters' failures and a day or two digesting Dr. Hill's 511 pages of *The Science of Ventilation*, will soon convince the reader of the enormous mass of work which went to produce this triumph of applied theory. The theory itself is given in several papers before the Royal Society (see Bibliography), and is far from simple, so may be omitted here, but a description of the instrument (Fig. 7) is of more general interest.

It consists essentially of a large-bulbed alcohol thermometer designed for the ready measurement of its own rate of cooling from 100° F. to 95° F. This range of temperature is chosen to give a mean of 97·5° F. (36·5° C.), which is approximately that of the clothed body surface. A bulb about 4 cm. in length and 2 cm. in diameter of known area, with a stem 20 cm. long has been found to give a sufficient time-interval for accurate observation so long as the temperature of the air is below 90° F. or over 105° F. The top of the stem terminates in a small reservoir, which gives a margin for overheating the instrument without bursting the bulb and also allows the cooling to settle down to a steady rate before the 100° mark is reached. A thin muslin finger stall is supplied with each instrument so that either dry or ordinary wet kata readings can be taken.

The dry kata reading gives the cooling power by radiation and convection, while the wet kata gives the cooling power by radiation, convection, and evaporation, that is, the total cooling power of the ventilating current. The dry kata reading is sometimes used for quite a different purpose, namely, to measure the velocity of air currents when they are moving very slowly.

(*To be concluded.*)

Commercial Motors.—The fifth International Commercial Motor Exhibition was held at Olympia, London, from October 14 to 22. A large number of motors were on show that are applicable for haulage to and from mines, and there were also many tipping motors that are in demand among mining men. Among the makers may be mentioned the following: The Daimler Company, Ltd., Ransome, Sims, & Jefferies, Ltd., Walker Brothers (Wigan), Ltd., Leyland Motors, Ltd., Fodens, Ltd., Tilling-Stevens Motors, Ltd., The Maudslay Motor Co., Ltd., John I. Thornycroft & Co., Ltd., Karrier Motors, Ltd., The Sentinel Waggon Works, Ltd., and Sheffield Simplex, Ltd.

A HISTORY OF MINING IN CHILE

By F. BENITEZ, A.R.S.M., D.I.C., Assoc.Inst.M.M.

INTRODUCTION.—Mining is intimately connected with the settlement, development, and even with the discovery of all that portion of the American continent colonized by the Spaniards. Unlike that heroic band of Pilgrim Fathers, who sought refuge in New England to escape religious persecutions and to be able to follow in peace the same callings and occupations as of old, the no less heroic Spanish adventurers who came to America did so with the hope of quickly bettering their fortunes in order to return to Spain to lead a life of ease and luxury, or were simply led there by a spirit of adventure. Greater contrast cannot be imagined than that existing between the Spanish Argonauts and the English Puritans. Comparing Pizarro and Cortez, Valdivia and Almagro, Ojeda and Mendez with Brewster, Bradford, Carver, and even Standish, we find nothing in common in both types except the same dauntless energy, grim determination, and finality of purpose. There the resemblance ends. The Spaniards were primarily men of war, soldiers of fortune first and last, seekers after something more solid than all the glory won in France, Italy, and Flanders. The Englishmen, deeply righteous and men of peace, emigrated in search of religious freedom, the thing above all others that they sought. It is well to bring out the great difference between the two types of men who were the progenitors of the two great races of the American continent, because in them we shall find not only the reason of the great contrast which the slow and peaceful settlement and growth of the United States and Canada offer to the imperfect and turbulent development of the Spanish-American republics, but also the key to some of the differences in the psychology of the two races.

The foremost thought of the early Spanish adventurers who came to the New Continent, which they imagined to be India and the islands of Japan, was to become rich quickly in order to return to the Peninsula. The idea of settling in the New World never entered their minds, and as agriculture—the only other possible occupation in a new country—was too slow and unremunerative an undertaking for their adventurous and fickle nature, it is not surprising that the greater number turned to mining as the most rapid means of acquiring wealth. The great quantities of gold, precious stones, and silver which the Incas of Peru had accumulated in their temples and palaces, perhaps through centuries of hard toil, fired their imagination, and a most active and thorough search for the source of the precious metals took place. The story of their adventures makes most wonderful reading, and for a record of mad audacity, unbounded faith, and heroic courage it has no equal in history. On the other hand, the Puritans came to New England accompanied by their wives and families. Their wish was to settle quickly and to form a colony as soon as a suitable site was found. Encumbered as they were by their women folk, they did not travel far, nor did they mix with the native population. The result was that for centuries the English settlers only colonized a long and narrow strip of land along the Atlantic coast from the St. Laurence to the Savannah river, and the rush westward came a long time after and under different conditions. Very different from this was the colonization of Spanish America. Most of the early Spanish soldier-miners who followed Columbus were young and unmarried. Their dominating desire for gold was for ever compelling them to hunt for that mythical El Dorado, the goal of their ambitions, and, as a consequence, in a comparatively short space of time, little more than a century, they had explored the greater part of the American continent, from Northern Mexico to Cape Horn, and from the Atlantic to the Pacific coast. When tired and disappointed in their search, they would rest awhile until the gold fever would take hold of their souls again, and their peregrinations would start once more. We see, as an example, that many of the soldiers who came with Valdivia for the conquest of Chile had served with Cortez in Mexico, under Pizarro in Peru, besides having fought in Central America. The Spaniards married freely Indian women, and the result was a mixed race, Spanish on the father's side, Indian on the mother's. Spanish women did not come to America in large numbers until a great many years after the conquest was ended ; for in those early days ships were scarce and small and the space available was far too valuable to waste on women when men and horses, cattle

and plants were so badly needed to carry to completion the formidable enterprise Spain had so lightly and ignorantly undertaken.

Another important fact must be taken into consideration when finding reasons for the great differences in the development of English and Spanish America. The English colonists, as has already been said, were primarily farmers. Agriculture binds the man who cultivates the soil to his land, and he becomes part and parcel of it. He takes root in his ground, as it were, much as the trees and the corn that he plants do; he learns to love it, and in the end passes it on to his sons, and these, in their turn, to theirs. The United States was first a farming country, then an industrial one, and lastly mining developed. Mining is a permanent industry in a particular place or district while the mines continue to pay. When the deposits are worked out or become impoverished so that they cannot any longer be mined at a profit the population that lived on the mines moves elsewhere and the mining camp becomes deserted. Some of the first Spanish settlements were mining camps. Therefore they were not, they could not, be permanent.

Gold.—The early inhabitants of Chile, or "mapuches," lived in the Stone Age, until conquered by the Incas of Peru at the beginning of the fifteenth century, from whom they learned the art of mining. When the Spaniards Almagro and Valdivia travelled southward from Peru into Chile they did so in the hope of finding great abundance of the precious metals, being misled by the wonderful tales the Peruvian Indians told them about the great wealth of gold Chile contained. They were disappointed in their hopes of finding much gold in Chile, for, as it is well-known, Chile is not rich in the yellow metal. Only placer deposits were exploited in those days, the first being that of Marga-Marga near Valparaiso. This kind of mining increased greatly in the second half of the sixteenth century, and it is calculated that in those fifty years more than 72,000 kilograms of gold were recovered. The system of working the deposits was extremely crude and very cheap, as all the work was done by Indian slaves, who received no payment and only the barest means of subsistence from their masters. The risings of the Araucanian Indians during the whole of the seventeenth century compelled the Spaniards to exchange the pick for the sword, and as a consequence the production of gold decreased to about half that of the previous century. In the eighteenth century there was a renaissance of gold mining in Chile, brought about by the discovery of gold in vein deposits. No extensive goldfield was found, but many rich lodes were worked throughout the whole length of Chile, from Itata to the Atacama desert. The average production of gold is estimated to have reached about 1,000 kilograms per year in the first ninety years of the eighteenth century. This figure rose to 2,000 kilograms per year in the last ten years of the eighteenth and the beginning of the nineteenth century, but this last figure represents the high-water mark in gold production in Chile.

The causes which have contributed to the decadence of gold mining in Chile have been many. Chile, as has already been said, has never been rich in gold, and although its occurrence is widespread throughout the country, the ores are of low grade and the deposits of limited extent. So far no goldfield worthy of the name has been found in Chile. The great impetus which gold mining received under Spanish rule was due primarily to the active search made for the precious metal by the Spaniards to whom all other things were practically of no value. This is proved by the fact that under the Spanish régime more gold was produced than has been recovered since. Free labour in the form of Indian slaves, and the rudimentary and cheap methods of exploitation used were also contributory causes to active production in the early days. Thus the gold-placers and the richest and most accessible vein deposits were worked out first. Later the struggle for independence coupled with the unsettled state of the country caused a reduction in output. Lastly the growth of trade with foreign countries, a direct result of the declaration of independence and free trade, directed the mining activities of the country to copper and the nitrate fields.

Silver.—Although more plentifully found in Chile than gold, the Spaniards gave very little attention to silver, which being devoid of value to them as a medium of exchange was not so necessary to them as gold. Moreover, silver is not found in placer deposits, but in veins, and as vein mining presented to the Spaniards, lacking as they did even the most rudimentary equipment, an undertaking far more difficult of solution than the simple washing of river gravels carrying detrital gold, it is not surprising to find

that silver received no serious attention under Spanish rule. Even supposing that the difficulties of mining the silver ores had been surmounted satisfactorily, the Spaniards would have been faced by a still more unsolvable problem in most of the mines, namely the successful metallurgical separation of the silver from the elements combined with it. The chief silver minerals found in Chile are proustite, pyrargyrite, and cerargyrite, though native silver has been found in great quantities occurring in veins in limestone.

The beginning of the eighteenth century marks the serious commencement of silver mining in Chile, though in those early days a few unimportant deposits were worked in the provinces of Santiago and Aconcagua in Central Chile. Towards the end of the eighteenth century the very important deposits of the department of Copiapó in the province of Atacama began to yield their rich ores, but the great epoch of silver mining in Chile does not correspond to the colonial régime, but coincides with the declaration of independence in the nineteenth century. Many were the rich silver mines discovered in Chile during the nineteenth century. That of Agua Amarga in Vallenar was the first to be worked. Then followed that of Arqueros in Coquimbo, and the famous Chañarcillo and Tres Puntas in the department of Copiapó. Another famous group of mines were those of Huantajaya, near Iquique. Caracoles (1870) was another famous silver district situated in the province of Antofogasta. The Condes mines near Santiago, now worked for copper, yielded considerable quantities of gold and silver from the upper levels. Of these mines the most famous and rich were those of Chañarcillo, which from 1832 to 1859 produced $60,000,000 worth of silver. The Huantajaya mines produced $22,000,000 of silver.

The value of the production has, like that of gold, decreased considerably, and silver mining to-day is only a shadow of what it was, especially in the second half of the nineteenth century, when between 100,000 and 200,000 kilograms of silver were produced annually. In the present century the annual production has never reached more than 70,000 kilograms per year (1900 and 1901). The silver won lately has come from ores other than silver, especially since 1916, when out of 47,500 kilograms only 10,800 were derived from silver mines proper. The following table gives the production for the years 1907 to 1917 inclusive :—

Year	From Silver Mines. Kilograms	From other ores. Kilograms	Total Kilograms
1907	15,542	3,194	18,736
1908	23,926	19,643	43,569
1909	13,511	22,397	35,907
1910	11,964	22,994	34,956
1911	11,122	16,553	27,675
1912	9,760	20,418	30,178
1913	11,744	17,507	29,252
1914	9,847	17,598	27,445
1915	8,712	16,525	25,238
1916	10.780	36,660	47,440
1917	10,533	42,860	53,393

Undoubtedly the chief causes of the decline in the production of silver is due to the exhaustion of the bonanzas found in Northern Chile, from Coquimbo (latitude 30° S.) to Iquique (latitude 20° S.) in the last century, and to the fact that no new deposits of the importance of the old ones have been discovered. In several districts the mines were abandoned on reaching a depth of 500 ft., while in others rich ores have persisted to depths exceeding 1,000 ft. To what extent the mines were abandoned owing to impoverishment in depth, faulty management, or lack of equipment, is a debatable point ; but the probabilities are in favour of the last. To those who are well acquainted with the primeval methods of mine exploitation still in vogue in almost all the Chilean mines, where no modern machinery is used and no systematic exploratory and development work is carried out, it is clear that only the very rich ores would pay to mine in those days. It is the opinion of many mining engineers well acquainted with the country that many of the silver mines now abandoned and full of water would pay good dividends if properly equipped and scientifically exploited. Yet another reason for the decreased production is the antiquated method employed for extracting the silver, namely amalgamation, which only gives a poor recovery. Cyanidation, in spite of its general application elsewhere, has yet to be introduced seriously in Chile. The fall in the price of silver has been also a contributory cause to the decline in silver mining ; for whereas in the second half of the last century, the great epoch of silver mining in Chile, the metal was quoted in London around five shillings per ounce, since 1900 it has stood at about two shillings previous to the recent boom.

Copper.—For much of the information I give here relating to the history of copper

mining in Chile, I am indebted to a most interesting lecture delivered by the Chilean engineer, Don Santiago Marín Vicuña, at the National Library in Santiago dealing with this subject.

According to two old Spanish chroniclers, Mariño de Lobera and Garcilaso de la Vega, copper mining was carried on in Chile during the domination of the Peruvian Incas, who extended their conquests to northern Chile and taught their rudimentary art of mining to their less civilized neighbours, or "mapauches," as the aborigines of Chile called themselves. There is ample evidence furnished by the discovery of very old workings made by the ancients, where crude wooden tools such as hammers, shovels, and gads, leather "capachos" or skin bags, as well as mummies of the Indians themselves, have been found, that the Indians mined for copper, probably in the native form, which they utilized for domestic uses and for arms; while the oxidized minerals, which are of such abundant occurrence in the north were used in the making of ornaments. The Spaniards, however, paid very little attention to copper, and it was not until 1600 that they started to mine for it. The demand for copper in Chile arose out of the necessity in which the Viceroy of Peru found himself of making guns for the defence of El Callao and other ports in his jurisdiction from the depredations of English corsairs and pirates, who in those days infested the coasts of the South Pacific. The metal was found to be of such good quality that a demand for it came from Spain itself for the same object. Though since 1600 copper was mined in Chile uninterruptedly the industry did not reach much importance until after the declaration of independence which opened to Chile the markets of the world. In those early days of copper mining only the very rich deposits near the coast were exploited. Many were the causes which contributed to the stagnation of the copper industry in those times. The means of transport were very inadequate; the demand for copper was not great, and its price was low; the methods of exploitation were most rudimentary; and last, but not least, Spain levied a tax of 20% on all exports, the so-called "quintos reales." Strange as it may appear to-day, copper could not be exported through any of the Chilean ports, and had to be sent either to Buenos Aires via the Andes and Mendoza on muleback or to Callao in sailing-ships in order that the proper authorities might control the famous "quintos." No wonder, then, that under such conditions copper mining could not prosper, and that only when the declaration of independence brought about the elimination of such childish and pettifogging restrictions could the industry attain a vigorous and healthy development. During the first two centuries of copper mining in Chile, the sixteenth and seventeenth, the production was only 70,000 tons, or less than a year's production nowadays.

Vicuña Mackenna, one of the most distinguished of Chilean publicists, writing on the growth of the copper industry, described it thus: "Copper was born in our mountains in a plebeian cradle, and thus lived for nearly three centuries; then labour, industry, commerce, and science, together with liberty, made of it a noble potentate."

The following table gives the copper production of Chile up to 1918, in metric tons.

Years	Total output. Tons	Annual average. Tons
1600–1699	4,600	46
1700–1799	62,200	622
1800–1899	1,764,680	17,646
1900–1918	850,720	47,260
Totals	2,682,000	8,434

Production from 1898 to 1917.

Year	Tons	Year	Tons
1898	26,341	1908	42,097
1899	25,719	1909	42,726
1900	27,715	1910	38,232
1901	30,155	1911	36,420
1902	27,066	1912	41,647
1903	29,923	1913	42,263
1904	31,025	1914	44,665
1905	29,126	1915	52,341
1906	25,829	1916	71,289
1907	28,863	1917	102,527

It was not until a third of the eighteenth century had elapsed that copper mining reached much importance in the country. The struggle for independence had absorbed all the energies of the people, and the severe taxation imposed to furnish the necessary funds for the army and navy of liberation had left the nation very poor. Labour was scarce, too, for all the manhood of the country was in arms against Spain. Though Chile achieved earlier than any other Latin-American republic a stable form of representative government, and though the steadiness of her political institutions from the earliest times offer to the world the only example of a true constitutional

development worthy of the name among the welter of revolutions for which the South-American continent has become famous, the country cannot be said in truth to have reached political peace and a definite form of government until the promulgation of the Constitution of 1833. From this date copper mining, though subjected to periods of depression, the causes of which will be analysed later, has reached great proportions, and the total value of the copper exported in 1918 was 60,000,000 dollars.

In the early days only the rich deposits situated near the coast were worked. The system used was the open-cut, and the mines were worked from the outcrops down. The rich oxidized ores were smelted in charcoal furnaces of oval shape, made from baked earth and perforated at regular intervals by a series of holes to establish a draught. Near the hearth there were two openings, one to tap the copper, and the other to admit an air-pipe leading to powerful bellows to increase the natural draught. The ore and fuel were charged in alternate layers. The wood used as fuel was cheap, for in those early days the districts round Coquimbo and Copiapó, where copper mining and smelting began, were heavily forested, though to-day they are devoid of trees. This early method of smelting was essentially a reduction of oxidized ores by charcoal, and was the only kind of smelting known and practised in Chile for over a century, until a distinguished English metallurgist, Charles S. Lambert, introduced the reverberatory furnace in 1834. Chile owes to Lambert a great debt of gratitude, for until his arrival in the country scientific and modern methods of smelting were totally unknown. Lambert was a graduate of the famous Polytechnic School of Paris, and came to Chile as assayer to an English mining company operating at Copiapó. He was long and honourably connected with mining and smelting operations in Chile, where he acquired a large and deserved fortune, and he died in London in 1877. Besides the reverberatory, he also introduced the blast-furnace, the steam-engine, stamps, sulphuric-acid making, concentration, and the use of coal in smelting ; but of all these innovations none was of such paramount importance as the reverberatory furnace, which soon made Chile the leading copper-producing country in the world. At the time of Lambert's death (1877) Chile produced more than half the world's copper.

One of the most famous copper mines of Chile in those days was that of Tamaya, near the town of Ovalle, in the province of Coquimbo. This renowned mine, reputed to have been the richest in the world, is said to have contained a "royal" or "mother" vein, fourteen yards wide, with an average tenor of 60% copper. The owner of the property was very successful in the treatment of the oxidized portion of this magnificent ore-body, but could do nothing with the ore from the sulphide zone, for in those days the smelting of sulphide ore was unknown in Chile. Ludicrous as the fact may appear to us to-day, sulphide ore was regarded as waste by the miners of that epoch, and was either thrown on the dumps or kept in the mines as filling material. Therefore, at that time the reaching of the sulphide zone was to the miner the end of his mine, the death of his hopes. The Chilean mining expression, "Se bronceó la mina," which means that the region of sulphide ore has been reached, became synonymous with the English "petering out" ; for, as sulphide ore was not marketable in those days, from a financial point of view, the mine was as good as exhausted. Lambert, who was already in the country, heard of the great riches of the Tamaya mine, then famous throughout Chile, and visited it in 1834. He marvelled at so much wealth lying idle, both inside the mine and out, and proposed to the owner to pay for the ore at the flat rate of an "onza" per day, or seventeen dollars. The owner, a most worthy gentleman, accepted, not without some misgivings as to the right mental balance of the Englishman, and in order to be in peace with his religious conscience insisted that a proviso be inserted in the contract whereby no dues were to be paid on Sundays or any fête days consecrated to the Holy Catholic Church.

When the rich and easily accessible deposits became exhausted, the production of copper in Chile decreased rapidly, and in 1882 the United States displaced Chile as the leading copper-producing country in the world. In a period of twenty years, from 1877 to 1897, the production had decreased from 47,000 to 21,000 tons.

From this brief description of the history of copper mining in Chile, it can be seen that the industry has been subjected to many fluctuations and vicissitudes. Three distinct periods of great activity in copper

production can be seen. The first corresponds to the exploitation of the rich oxidized portions of the most accessible deposits, which were mostly situated in the Coast Range or in the spurs of the Andes that run towards the coast and form the transverse valleys. These rich, oxidized ores were smelted in charcoal furnaces. The methods of mining were most rudimentary, as no mechanical equipment was used. The smelting, too, was simplicity itself. Labour was plentiful and very cheap, The second corresponds to the introduction of the reverberatory furnace, which allowed the sulphide ores, regarded as untreatable until then, to be smelted. In this second period, which lasted from 1834 to 1880, the copper produced came from the zones of secondary enrichment of the mines whose oxidized regions had been worked in the previous epoch, and from many newly discovered deposits from which only the richest ore was taken out. All these mines were situated in regions of easy accessibility; for the methods of working were still very little better than those of the previous period, and with any such methods only rich ores could pay the heavy mining costs and dear transport rates of those days. From 1880 to 1908 the yearly output was much below those years when Chile occupied first place among the nations as a copper-producing country. The reasons for the falling off of production are not difficult to discover. In the first place the richest and most accessible deposits had been worked out. Modern equipment and sufficient capital were lacking, as the nitrate fields were attracting preferably the local savings. The railway system of the country was very undeveloped, and labour was much dearer and scarcer, owing to the demands of the nitrate fields. The last period begins in 1908, and corresponds with the arrival in Chile of powerful foreign capital, first English and French, and later American. It is the era of modern machinery and methods, of the blast-furnace, flotation, and lixiviation. It is characterized by the courage, energy, and method with which American capital, scientifically directed, has attacked such tremendous undertakings as Teniente, Chuquicamata, Potrerillos, and La Africana. It is the day of the big low-grade deposits in the inaccessible regions of the Andes and of sound scientific mining engineering.

The successful development of the four great American companies in Chile, two of which have reached the producing stage, have proved conclusively that low-grade propositions are just as susceptible of profitable operation in Chile as in the United States, in spite of the much greater natural obstacles to be overcome, distance from base of supplies, and cost of transporting the produce to New York for refining or sale, if sufficient capital is provided and the management is entrusted to engineers of proved ability and experience in large-scale operations of this kind. It is my opinion that in the future the American companies operating in Chile will be able to produce their copper for several cents less than those operating in the United States, probably at about 7 or 8 cents per lb.

There is no question that local capital would not have dared to tackle such enterprises as the low-grade copper deposits of Chile, which demand the investment of millions of dollars before the producing stage is reached. Native capital is shy and conservative, and though adventurous enough for mining on a small scale, it would not have braved the big undertakings, where the payment of dividends might be long deferred, owing to its lack of experience in financing, engineering, and management.

It may be said confidently that the bulk of the copper produced in Chile in the future will come from the large low-grade mines. Whether Chilean capital, inspired by the example set by the American companies, will take heart and develop some of its own low-grade deposits is a moot question. If it does it will have to abandon its timorous present methods of financing and management, and above all repent of its inveterate love of share juggling at the Bourses, of which we have had so many glaring examples of late. Mining, we all know, is a legitimate gamble. The phrase has so often been repeated and accepted by everybody that it has become a common truism; but its meaning only holds true so long as the interests of the shareholders are dutifully safeguarded by directors and management alike. When these inflate or depreciate, bull or bear the stock of a mining company to further their own ends, the operation is neither mining nor gambling. It simply becomes common straight swindling. There has been too much of this sort of thing in Chile of late. The sooner it is abandoned the better for all concerned.

MINING CONDITIONS IN CHILE.—From the conquest to the declaration of independence, mining in Chile, as well as in all the other Spanish colonies in America, had to bear a very heavy duty in the form of the famous and much hated "quintos reales," which consisted in the payment to the Spanish Royal Exchequer of 20% of the total value of the mineral produced. Mining was a profitable undertaking in spite of such a burdensome load, owing to the fact that the miner could draw upon a large and cheap supply of Indian labour. This labour was so cheap that it received no payment in cash, and only sufficient food to keep it alive. Towards the end of the eighteenth century slavery was abolished in Chile. After the abolishment of slavery the wages paid to the Indian and "mestizo" miners were very low, and not until the middle of the nineteenth century did they rise perceptibly. The rise in wages coupled to the gradual descent in the price of silver at that time caused a slump in the production of that metal. The fluctuations in the price of copper also militated against the steady production and growth of the copper-mining industry; and though the miner after 1810 was no longer compelled to pay the exacting tribute of 20% to Spain, this advantage was offset by the rise in wages and the low price of the metals.

In those early days the production was greatly encouraged by the very cheap means of transport, for, though the roads were very bad and far between, the miner was entitled by law to graze his animals in neighbouring pastures without any payment on his part. The wood for smelting the ores could also be obtained for nothing from the near-by forests round the districts of Coquimbo and Copiapó, in those days plentifully supplied with trees, though to-day sadly deforested by the wanton and blind destruction brought about by the local smelters.

All the gold produced in Chile in early times was recovered by the Indians in the "batea," the Spanish equivalent of the English pan. Not until the seventeenth century did the "trapiche" or crude forerunner of the Chilean mill make its appearance. In the eighteenth century amalgamation was introduced in Chile, chiefly in connexion with the extraction of silver from its ores. Copper ores, until the introduction of the reverberatory furnace, were always smelted in the crude mud-baked furnaces already described. The mining and metallurgical methods employed until recent times have always been of the crudest. According to a historian, even in the early days of the nineteenth century, there was not a single trained metallurgist in Chile.

LETTERS TO THE EDITOR

Indian Mining Laws

The Editor:

SIR—Your Editorial and extract from the *Journal of Indian Industries and Labour* set out the principles that govern the granting of prospecting licences and mining leases in British India, and present the views of the Government of India on its own laws.

Having been mining for some years in this country I think it desirable that the views of some of those who have to work under these laws should also be presented, and that certain failings in them should be pointed out.

Too much is left to the discretion of the Deputy Commissioner or Collector of a district, who is not infallible, and the rules are not sufficiently binding to prevent favouritism, influence, or persuasion from affecting decisions.

To commence with, anyone is at liberty to explore for minerals, but no discoverer is allowed to take out a licence or lease on what he has found unless he be granted a certificate of approval from Government, that is, the Deputy Commissioner or Collector of the district. In other words, that he be considered by this individual to be a "fit and proper person."

Cases have arisen in which certificates of approval have been held under some collectors and renewal refused under others, and vice versa. Also a person while working for a firm may be considered "fit and proper," but may be no longer so when he wishes to do some prospecting on his own. In the event of a refusal, appeal can be made to the local Government, but the chances are greatly in favour of the district official being supported, and the Government are not obliged, and often decline, to give any grounds for such refusal. If prospecting is to be stimulated, the finder should be in a position to reap the reward of his labour. Where the application for a prospecting licence has to go up to the local Government, the licence may take anything from six to eighteen months, or even longer, before it is executed.

No limit is placed on the area taken up under a prospecting licence, with the result that a big company can tie up such parts of the country as seem desirable for a period of three years.

In mining leases, the royalties discriminate between precious stones, gold and silver, and other metals and minerals, while that on iron ore is absurdly low even allowing for a desire to stimulate the iron and steel industry of India. The minimum rates can be exceeded in the event of the deposit proving to be of more than normal value, which is not only ambiguous, but would seem to preclude the miner or investor from reaping the full benefit of the occasional windfall and encouragement necessary for further effort alluded to in your Editorial. In the event of any disputes occurring regarding licences or leases the decision of the local Government is final, though it has no official with sufficient technical knowledge to arrive at a correct decision, the Mines Department being under the Government of India.

Turning to prospecting and mining generally, encouragement varies with the officer in charge of the district, and the backing behind the prospector; while travelling in areas remote from the railway is practically dependent on the support of the local authorities.

Again, in some districts where roads have been made these are closed to both lorry and tractor traffic when no other routes are available, and one is obliged to fall back on the prehistoric bullock cart, which makes mining impossible.

The lack of encouragement to the small prospector and his inability to procure a licence has often in this country led to the premature flotation of large companies, before the necessary development work has been done, with, generally, disastrous results.

E. O. MURRAY.

Takanagar, *September* 27.

Oil in Sussex

The Editor:

SIR—The recent reports in the daily Press of the occurrence of oil in a water-well at Bosham, near Chichester, recall to mind a similar discovery at Peterborough some years ago, when a leakage from surface stores caused the "mysterious" accumulation; in this more remarkable instance in Sussex we are informed that over 100 gallons of oil have been obtained, and, further, that there are no contiguous stores from which it could possibly have been derived. Under these circumstances the belief has grown that the occurrence is a natural one, and already an inspector from the Petroleum Department has paid a visit to the well.

In the *West Sussex Gazette* of October 13 last, a short account of this visit to the Bosham well was given, and it was stated that "the inspector made no definite pronouncement on the subject, but it was gathered that he was distinctly of opinion that the oil is 'natural oil,' and not the result of some fortuitous leakage from surface stores." This, of course, is yet another example of that curious optimism prevalent whenever a new "oil discovery" is made in this country, an optimism which takes no account whatever of the obvious technical difficulties existent. The result is that there are already people who believe that at Bosham we have a potential British oilfield, and who are presumably only waiting in anxious anticipation of the prospectus of the company which might possibly be formed to undertake its development! Let us glance briefly at the scientific facts.

Bosham is actually situated on chalk, here brought to the surface by an east-west flexure known as the Portsdown Anticline; we may regard this fold as a subsidiary element of the main Weald structure; it has, in fact, a tectonic relationship to the main chalk outcrop of the South Downs. We may therefore admit the existence of a favourable structure to oil accumulation at Bosham, but that is unfortunately as far as we can agree with the "optimists." Chalk and oil do not mix, either physically or genetically. This may seem an unpardonable platitude, but the remark is necessary, since under no circumstances can the oil be indigenous to the chalk at Bosham, the latter rock being essentially a permeable deep-water deposit. Whence can the oil have come? If a natural occurrence, it must have been derived from a much older stratigraphical horizon. We may rule out at once the Lower Cretaceous beds, as these are quite barren of oil wherever met with in South-Eastern England. We have, therefore, to estimate the probabilities of the Jurassic rocks, more especially the Kimmeridge Clay, that inevitable "bonanza" of the advocates of oil-finding in Eastern and South-Eastern England. Now, quite apart from the facts that the Kimmeridge

Clay is lithologically unsuited to the existence of large quantities of oil, since it contains no intercalated sand lenses as storage pools, and that nowhere in this country has it yet yielded even a small amount of natural crude oil, its great depth of location beneath Bosham is such as to preclude the very slightest chance of the oil having migrated thence to its present position, particularly when we consider the intervening impervious horizons such as the Purbeck shales, Weald and Gault Clays. Thus geologically the possibilities of this oil being a natural occurrence are practically negligible.

To the writer a simple explanation of the facts presents itself. Bosham has a tidal creek, which drains into the Chichester Harbour, the latter having direct communication with the Channel. In these days of oil-fired ships and oily sea-water, floating oil may well occur, and under favourable tidal circumstances find its way to Bosham Creek. Local contamination of water wells would ensue if by any means the tidal water got access to the ground water, by no means an impossibility in an area situated as Bosham is. Whatever be the explanation, however, it is certain that on geological grounds no natural accumulation of oil can be expected here, and the public would be well advised to accept this and any future reports of a like character, with the utmost reserve.

H. B. Milner.

London, *October* 25.

BOOK REVIEWS

Technical Methods of Analysis. Edited by R. C. Griffin. Cloth, octavo, 660 pages, illustrated. Price 33s. New York and London: McGraw-Hill Book Company.

This work, the latest member of the well-known "International Chemical Series," constitutes "a representative selection of analytical methods which have been adopted as standard procedures in a large commercial laboratory engaged in technical analysis." In view of the enormous field covered to-day by the term "technical analysis," it is obvious that, to keep the bulk of the work within reasonable limits, and at the same time to describe the processes in sufficient detail, some of the sections escape the thoroughness of treatment to be found in larger works. Nevertheless, in some 600 pages the author has contrived to include a vast amount of information upon subjects of great diversity.

The work is divided into eleven chapters, each of which is devoted to a particular branch of analysis. In some of these chapters the necessary compression has resulted in unevenness of treatment, but in most instances the omissions are not serious. The first chapter deals with the preparation of reagents, standard solutions, and indicators, and with the care of platinum ware. Then follows a chapter on general inorganic analyses, where in forty odd pages a number of typical determinations are given, including such diverse materials as table salt, native sulphur, and agricultural insecticides. In the next forty pages methods are given for the examination of thirteen organic compounds of commercial importance.

The section of the analysis of metals is one which betrays lack of uniformity in treatment. The whole range of metallurgical analysis, both ferrous and non-ferrous, is disposed of in sixty pages. The sampling of iron and steel receives little more than one page. One reliable method is given for each constituent of straight steels and pig, while alloy steels are adequately treated. Brasses, bronzes, white metals of all types, and nickel silvers receive detailed consideration. The commercial analysis of spelter is described, but no reference is made to crude or refined copper, soft lead, or the various grades of gold and silver bullion. This chapter confines its attention to the metals themselves, and omits the consideration of the metallic ores, with the exception of those of tin. We should hesitate to employ the method given in the latter case for any but the cleanest or richest of materials, although the situation is saved by a reference to the assay of solder, described elsewhere in the chapter.

Succeeding chapters deal with solid, liquid, and gaseous fuels, paint, oils, fats, waxes, soaps, paper, materials, textiles, and foodstuffs, while in a final chapter devoted to "Miscellaneous Analyses" we find such strange bedfellows as boiler waters, leather, soldering, paste, and portland cement. The presentation of the book is admirable, in the style familiar to the readers of the previous works of the series. The book is not free from the orthographical blemishes common to most books of American origin, while here and there a looseness of expression is noticeable, not such, however, as to be of serious import in a book of this nature.

No attempt has been made to include the treatment of gas analysis, or the analysis of minerals metallic ores, rocks, the rare metals, or of organic dyes and drugs, nor has space permitted any mention of the theoretical aspect of the subject. While much has of necessity been omitted, the methods given are in the main up to date and sound. The information given is supplemented by numerous references to current literature, and to government publications, while the omissions are compensated for by an excellent bibliography of all branches of chemical analysis. Though both the student and the specialist may occasionally seek for information in vain, the book should prove of value for general reference.

B. DRINKWATER.

Mine Accounting and Cost Principles. By T. O. McGRATH. Cloth, octavo, 260 pages, illustrated. Price 24s. net. New York and London: McGraw Hill Book Company.

The exploitation of large mining fields, the operating of low-grade mines, and the control of a number of mines by one company from a central office, have all assisted the growth of a highly organized method of mine accounting and costing. Within the British Empire, mining fields such as the Witwatersrand, Kalgoorlie, and Kolar, have done much to place mine accounts and mine book-keeping on a regular basis. In the present work Mr. T. O McGrath, an experienced American mine accountant, presents details of American mine accounting and cost principles. The object of the author, as set forth in the preface, " has not been to exhaust the subject of accounting and costing as applied to mining, but simply to state the principles and to present sufficient forms, charts, records, and procedure to illustrate how the principles are applied in actual practice." Articles have appeared from time to time in American technical papers giving details of accounting and costing at different mines, but in this book the general principles of the subject are given clearly and concisely, and an appeal is made for the standardization of this branch of American mining administration. The author frankly admits the difficulty of applying one method and set of forms and charts for all mine accounting, and the impossibility of attempting such a thing for costing, but at least there are certain general principles that can be followed in every instance which will facilitate comparison at different mines.

Mr. McGrath deals with his subject in an interesting and orderly manner; first, in order to determine the basis of the accounting, the business is analysed and a statement of the principles of the mining business is drawn; second, charts of accounts are created which correctly reflect these principles upon the ledger; third, schedules are drawn showing the charges and credits to these accounts to ensure uniformity and correctness; fourth, books and records are created that will allow the compiling of operating and business data so as to give a balance-sheet showing the true condition of the business and a profit and loss statement that gives the results of a period's operation. The section on cost accounting deals with units of organization of work and equipment, expense, cost factors of production and operation, and time, and closes with examples of compiling the costs. The book should be very useful to mine accountants and mining engineers. The McGraw-Hill Book Company are the publishers and, as is usual with this firm, the book is handsomely bound and printed in clear type on good paper.

A. YATES.

First Aid and Rescue Work in Mining. By LOUIS G. IRVINE, M.A., M.D. Limp cloth, pocket size, 360 pages, illustrated. Price, 8s. 6d. net. Johannesburg: The South African Red Cross Society; London: THE MINING MAGAZINE.

Although statistics show that from the standpoints of health and safety mining compares very favourably with other industrial occupations, all serious attempts to increase the efficiency of emergency work in dealing with accidents are worthy of attention. Promptly applied, a knowledge of first aid may sometimes save a limb and may not infrequently save a life. Efficient first aid often prevents dangerous consequences following upon an injury, and will always tend to lessen pain and suffering. These facts are so generally admitted that they are recognized in the legislation of those countries where mining is an industry of importance. Successful candidates for competency as mine managers in Great Britain must possess some knowledge of first aid, and in the Union of South Africa, on mines employing over 500 persons, every

official (a term which includes even the chief surveyor, the foreman smith, and the mine sampler) is required to be in possession of a certificate from a recognized ambulance association testifying that the holder is qualified to render first aid to the injured, with special reference to mining accidents.

In Great Britain, the Colonies, and the United States much valuable work has been done by associations specially formed to promote the study of first aid work on mines. As an excellent example of these organizations, attention may be drawn to the Yorkshire Collieries Ambulance League. Founded in 1906, it endeavours to disseminate knowledge of ambulance work by public competitions and exhibitions by teams of mine workers. The competition, as far as possible, is confined to practical mining work, and members of each team competing for the shield and medals must be employed at some one mine in Yorkshire. Associations on somewhat similar lines exist in many other important mining fields, as in the Transvaal. The South African Red Cross Society has done much to minimize the effects of accidents on the Rand, and at the request of their Executive Committee Dr. Louis Irvine, in 1913, prepared a small volume on *First Aid in Mining.* It was realized that in the mining industry there were liable to occur many accidents on which there was little or no specific information in the first aid manuals in general use. Among these may be mentioned blasting and "gassing" accidents, due to irregularities in the use of explosives and cyanide poisoning on gold mine reduction works. The transport of injured is also a subject which demands special attention underground, for it may be necessary to take a patient through passages of small sectional area at any inclination from the horizontal. The publication of eight years ago was only intended to deal with the requirements of metalliferous workers. Dr. Irvine's latest work is much more extensive in character. It deals with general practice and accidents peculiar to both coal and metalliferous mining, in a volume of 350 pages. The book, however, may be conveniently carried in the pocket. Part I, General Course in First Aid, may be regarded as an excellent manual for the requirements of the general reader and for those studying for ambulance team competitions. The avoidance of technical details of anatomy and physiology, as far as possible, adds considerably to the value of what is by no means an elementary treatise. Part II deals with First Aid and Rescue Work in mines. The divisions in mining practice which have long existed between coal and metalliferous work are being gradually broken down, to the advantage of both sections of the community, and engineers may claim that each branch of the profession is learning much from the other. Metal miners may be surprised to find that accidents from explosions from firedamp have occurred in gold mines on the Rand and in Australia. Though the coal miner may not run much risk of "gassing" by fumes from explosives, he may with advantage learn what are the possibilities of danger in this direction.

Dr. Irvine deals with the causes and effects of gas and coal-dust explosions and what methods may be adopted for the prevention of underground fires and explosions. He states that the chapter in his book on the "Use of Rescue Apparatus in Coal Mines" is intended to be a general indication of the scope and necessary limitations of self-contained breathing apparatus, with descriptions of the most important types. In 35 pages of a small book he gives, however, much more than the preface would lead the reader to expect. It is more than a practical introduction to the subject, and for those who wish to make a further study of mine rescue work he gives a list of publications which may be studied with advantage.

In a prefatory note to the book, Dr. J. S. Haldane, whose valuable work for the reduction of mining dangers is well known, says: "I most heartily commend the book to all English-speaking mining communities." Readers will generally endorse this statement. It is a first-class textbook for the miner who wishes to specialize on first aid. It is difficult to point out defects in this admirable publication from South Africa, and critics will find little for discussion, but one or two points may be raised.

Ammonia and bicarbonate of soda are mentioned as suitable reagents for the treatment of stings by insects, such as wasps, bees, and mosquitos. As it is frequently stated elsewhere that the poison from bees and wasps are of different character, being acid and alkaline respectively, different treatment is desirable.

It is a pity that a book of 348 pages, which merits long and careful study, and may be frequently used for reference purposes,

is not given a better binding than that which may be described as limp cloth. In many instances the volume may suffer disintegration before the reader throws it aside as of no further value, so it is to be hoped that in a future edition this admirable treatise will appear in a covering worthy of the author's efforts.

STANLEY NETTLETON.

The Metallurgy of the Non-Ferrous Metals. By Professor WILLIAM GOWLAND. Cloth, octavo, 631 pages, with numerous diagrams and illustrations. Third edition. Price 30s. net. London: Charles Griffin & Co., Ltd.

The first edition of this work was published in May, 1914; the second appeared during the war, in October, 1917; while the third edition has just passed through the printer's hands; there is thus an interval of seven years since the first appearance of this book. During this interval great advances have been made in the metallurgy of the non-ferrous metals, and it has been the author's aim that the present edition shall be absolutely up to date in every respect. A careful perusal of the book will show how thoroughly this has been done.

In the second edition Professor Gowland considerably expanded the sections relating to copper, zinc, nickel, and gold, and many descriptions were added of the actual equipment and practice at typical works. Fortunately this excellent method of indicating the principles on which new processes depend has been further extended in the present edition.

The book is divided into eighteen sections under the following headings: I, Refractory Materials; II, Roasting; III, Fluxes and Slags; IV, Copper; V, Lead; VI, Gold; VII, Silver; VIII, Platinum; IX, Mercury; X, Zinc; XI, Cadmium; XII, Tin; XIII, Nickel; XIV, Cobalt; XV, Antimony; XVI, Arsenic; XVII, Bismuth; XVIII, Aluminium. The plant and processes described are illustrated by no less than 217 diagrams.

In the section dealing with refractory materials, an account is given of zirconia, which, until comparatively recent times, was considered one of the rare oxides. This mineral is now found in large quantities in Brazil, Ceylon, Australia, and other parts of the world; it is one of the best refractories known, and is particularly useful for certain classes of electric-furnace work. The causes of the failure of silica bricks at very high temperatures are also discussed.

Under roasting the operation of nodulizing flotation concentrate is described. The process was originally used for certain classes of iron ore, but has since been adapted to the agglomeration of sulphide concentrates by heating them in revolving cylindrical furnaces.

In connexion with the metallurgy of copper, it is shown that the reverberatory is rapidly displacing the blast-furnace owing to the use of powdered coal and oil as fuel. However, the blast-furnace will not be completely eliminated, as, especially in many small works, and even in large ones, there are conditions when the blast-furnace can be advantageously used. The rapid advance of the flotation process for the concentration of copper ore is largely responsible for the increased use of the reverberatory, since the concentrates are very finely divided and are therefore unsuitable for smelting in a blast-furnace.

An interesting description is given of the Bunker Hill smelter and refinery at Kellogg, Idaho. Here the furnace product is not shipped as lead bullion, but is further treated and is eventually marketed as refined lead, silver, and gold. This plant is the newest and most complete of its kind in the United States.

The author points out that the chief recent advances in the metallurgy of gold have been: (*a*) The introduction of precipitation by charcoal at Yuanmi, West Australia; (*b*) The use of cyanide solution, followed by sodium sulphide solution for the extraction of gold in a carbonaceous schist; (*c*) A modification of Miller's process; (*d*) The increased use of the Crowe process. The last-mentioned process consists in removing all the dissolved air from pregnant cyanide solution by breaking it into a spray and submitting this spray to reduced pressure produced by a vacuum pump. The occluded air is thus removed from the solution. Dissolved oxygen in the presence of zinc causes re-solution of the precipitated gold or silver, hence the advantage of its elimination. The gold and silver are subsequently precipitated by means of zinc dust.

In the section relating to the treatment of mercury ores, important innovations are described, especially the revolving cylindrical furnaces at the New Idria mine and a Herreshoff furnace at New Almaden.

Under zinc, a description is given of the

new electrolytic plant of the Anaconda Company, and of the new plant of the New Jersey Zinc Company for the preparation of zinc oxide. Accounts are also given of new furnaces for roasting and distillation.

The work as a whole is particularly free from errors, typographical and otherwise, while its value is enhanced since the author has taken great care to give in the text the source of each quotation and illustration.

Professor Gowland states in the preface that his purpose in preparing this edition has been "to make it a useful standard of reference to the principles on which metallurgical operations are based and their application in modern practice, both to students and metallurgists engaged in their profession, and it is his earnest hope that this aim will be attained." We are confident that this desire will be more than fulfilled. Further, we would congratulate the author on the production of a volume which is not only of the utmost value to the student but also to the professional metallurgist.

W. H. MERRETT.

☞ Copies of the books, etc., mentioned under the heading "Book Reviews" can be obtained through the Technical Bookshop of *The Mining Magazine* 724, Salisbury House, London Wall, London, E.C. 2.

NEWS LETTERS

TORONTO

October 10.

PORCUPINE.—For some time there have been serious apprehensions of a shortage of electric power during the coming winter, which would considerably curtail mining operations. Owing to the drought which prevailed during the summer the level of the lakes and streams was unusually low, but recent heavy rainstorms have somewhat improved the situation. The demands of the mining companies for power, however, are about 25% greater than last year, so that it is still somewhat doubtful whether an adequate supply can be regarded as assured. The power company is building a dam which is planned to raise the main storage area by 10 ft., but it can hardly be completed in time to be of service this year. The leading producing companies are preparing to install auxiliary steam plants in case is should be found necessary.

The Domes Mines, in driving on the 7th level, has encountered a large ore-body, the gold content of which is stated to average $40 to the ton. It is of irregular outline, extending more than 30 ft. in one direction, but its dimensions have not yet been determined. The ore-bodies which are being opened up on the 1,150 ft. level have been found to extend downward for at least 200 ft. A rise is being made from the 1,300 ft. level on which development will be pushed before sinking deeper. The mill is treating about 1,000 tons per day, with mill-heads averaging $7·50.

The Hollinger Consolidated is handling an average of 3,500 tons of ore daily, and is planning to increase the capacity of its mill to about 5,000 tons per day, provided the necessary power can be obtained, by the addition of a ball and rod mill grinding equipment. It has now a force of about 1,800 men employed.

The McIntyre is clearing the site for its new mill extension, but delaying construction operations until conditions as to power supply become more settled. The company has purchased a large quantity of machinery for an auxiliary power plant as a precautionary measure against a shortage. Ore is being taken out at a depth of approximately 1,700 ft. of a high average gold content, surpassing that obtained from the upper levels.

The Allied Porcupine Gold Mines has now unwatered the Three Nations, and is planning extensive diamond-drilling and development work on the 200 ft. level. Work has been resumed on the Hayden-Porcupine, which has been closed down for some years. Extensive development disclosed mineralized bodies of exceptional width carrying low gold content. Diamond-drilling is in progress on the Rochester, which is under option to the Nipissing of Cobalt, with encouraging results. A shaft is being sunk on the March Gold. Operations have been resumed at the Davidson Consolidated. Lateral work is being carried on, and a contract has been let for extensive diamond-drilling.

KIRKLAND LAKE.—The Lake Shore during August produced $42,274 from the treatment of 1,979 tons, being an average extraction of $21·36 per ton. The mill ran 92·33% of the possible running time. The shaft of the Wright-Hargreaves, now down 400 ft., will be put down to 800 ft., with stations for levels at intervals of 100 ft. The mill is now treating an average of 160 tons of ore daily, with mill heads averaging $15 per ton. The Kirkland Lake is taking out ore from the 900 ft., stated to run $40 to the ton. The mill is treating

135 tons daily. Good progress has been made in the construction of the Ontario-Kirkland's mill. The heavy machinery is now installed and the mill will be ready for operation in about six weeks. There is a large supply of ore in readiness, stated to carry about $15 in gold per ton. At the Goodfish mine a shaft is down about 30 ft. on a vein showing gold across a width of 6 ft. A good discovery has been made on the Granby-Kirkland property, where a vein has been uncovered, showing rich gold content over a width of 5½ ft., with wall-rock well mineralized. Surface exploration on the King-Kirkland has exposed 32 veins, enabling the management to select the most desirable location for a central shaft, which will shortly be put down. Sinking operations are in progress at the Comfort-Kirkland, where an electrically driven plant has been installed. The Kirkland Lake Proprietary (1919) has decided to deepen the No. 3 shaft on the Burnside 70 ft., so as to make it a central shaft for the operation of both the Burnside and the Tough-Oakes. The Sylvanite is putting down a new shaft, and abandoning the old workings, which are considered too small. A meeting of the shareholders of the Teck-Hughes will be shortly called to ratify an agreement with the bond-holders for the reorganization of the company, which is stated to be satisfactory to the majority shareholders. Conditions at the mine continue favourable. The addition to the mill, which will bring its capacity up to 160 tons per day, is expected to be in operation before the end of the year.

COBALT.—Conditions in the silver-mining industry are steadily improving with the increasing price of silver and the decline in the cost of materials. The Nipissing is producing silver at a cost of between 30 and 35 cents per oz., and the operating expenses of the Mining Coporation, Coniagas, and O'Brien are well under 60 cents per oz., leaving a good margin for profit. The production of the Nipissing for August was estimated at a value of $197,536, of which $172,516 was silver and $25,020 cobalt. A new vein found at the second level of shaft No. 63 was driven on for 80 ft., of which 60 ft. had an average assay of 2,500 oz. over a width of 3 in. The La Rose Consolidated is now producing silver from four mines, which are yielding about 130 tons of ore daily. The vein opened up at the 570 ft. level of the Violet property is yielding some high-grade ore, and a large tonnage of good milling ore. The shareholders of the Oxford-Cobalt have authorized the purchase of the Waldman property, and two other claims, bringing their total area up to 100 acres. Liquidation proceedings in connexion with the Bailey Cobalt Mines, Ltd., which were begun ten years since, were concluded last month, when the shareholders authorized the directors to make application to terminate the winding-up process. The directors were authorized to receive from the liquidation 425,000 shares of the stock of Bailey Silver Mines, Ltd., to hold for the benefit of the Bailey Cobalt shareholders. The report of the Bailey Silver Mines for September shows that the earnings of the Bailey mill were approximately $13,389, from the treatment of 4,466 tons of ore. The Right of Way company is in financial difficulties, having debts of $34,000 and no funds on hand. J. P. Langley has been appointed receiver.

SKEAD TOWNSHIP.—An important ore-zone has been discovered on L.S. 30, one of the properties of the Skead Gold Mines, Ltd. Eight parallel veins have been found within a width of 225 ft., having an average width of 14 in. One vein, which has been stripped for 900 ft., shows an average gold content of $29 per ton. A mining plant will be installed and active development undertaken.

VANCOUVER, B.C.

October 12.

CONSOLIDATED MINING AND SMELTING.—A conference was held recently, at the Hume Hotel, Nelson, between the president, general manager, and comptroller of the Consolidated Mining and Smelting Company and representatives of the individual mine owners in the Slocan district, for the purpose of arranging a new schedule of smelting charges. The conference was convened at the request of the officials of the Consolidated Company, which means that it is in the market for custom ores once again. Since the beginning of the present year the smelting company has offered no inducement to independent mine-owners to ship ores to Trail, as it would pay for the metal contents of such shipments only in warehouse receipts, upon which the mine-owners were unable to raise any funds at the local banks. The result has been that practically all production ceased, although several companies continued development of their properties on a reduced scale. At the conference the company made a tentative

offer to pay for 95% of the silver content, based on "New York Foreign" quotations, and 90% of the lead, based on London quotation, until such time that the domestic demand should be equal to the production, when Montreal quotations are to replace London ones, regardless of the zinc content of the ore. Such payment is to be made 90 days after the day of sampling, but if requested the company will give 90 day notes on the day of sampling. These, of course, would be readily discounted at the local banks. In the matter of rate of exchange on the sale of silver, the company is to receive 3%, and everything over that percentage is to go to the shipper. The new schedule will give shippers several advantages over the old one, which inflicted penalties for zinc in excess of 10%, such penalties increasing with the increase in the zinc content. The company has reduced its proportion of the advantage of the exchange-rate from 5 to 3%. Several of the mine-owners feel for the moment that the offer is too good to be true, but if the company lives up to its offer the new schedule undoubtedly will give a considerable fillip to mining in the Kootenays.

The ore receipts at the Trail smelter for the first nine months of this year amounted to 307,493 tons, and have surpassed all previous records for the period. The receipts for the first nine months of last year amounted to 251,735 tons, and those for the similar period of 1919 totalled 258,323 tons. Nearly 98% of the ore received this year has come from the company's own mines.

The Consolidated Mining & Smelting Company has come in for a good deal of criticism for its attitude in pushing development and production at its own mines and at the same time refusing to buy ore from the independent operators. Undoubtedly it has been very hard on the latter, but unquestionably it has been beneficial to the mine and smelter workers of the Province, as it is doubtful whether the independent operators could have kept their mines running in the face of the depressed condition of the metal market in the same way that the Consolidated, backed by the Canadian Pacific Railway, has been able to do. It is to be hoped, now that the company is in the market again for lead and copper ores, that the independent owners will bury the hatchet and combine with the company to thoroughly re-establish the mining industry of the Province.

During the first six months of the present year the Consolidated Company produced about 24,000,000 lb. of lead and 26,000,000 lb. of zinc, compared with 26,474,652 lb. lead and 38,995,390 lb. of zinc for the whole of last year. The company has an immense stock of zinc on hand, but about only 14 million pounds of lead, or about four months normal domestic demand. The Canadian lead market is a good deal stronger than the zinc one, and the fact that the Sullivan ore averages about 18% of zinc and 12% of lead probably has been one of the factors that has brought the company into the market again for silver-lead ore, for by smelting a considerable proportion of lead ore with Sullivan ore it will be possible to maintain the lead production without appreciably increasing the large stock of zinc on hand.

Van Roi.—Clarence Cunningham, one of the principal Slocan mine operators, has relinquished his option on the Van Roi mine at Silverton. Mr. Cunningham obtained an option on this property for $225,000 in 1916, paying a large instalment two years later. Since that time payment has been made only in royalties on ore-shipments. All told, some $350,000 worth of ore has been taken from the mine since Mr. Cunningham took control, and the owner of the property has benefited to the extent of about $150,000. The Van Roi, like the Le Roi No. 2, is controlled in London, and these, it is believed, are about the only two mines that are so controlled out of a large number that at one time were directed from London offices. Since the erection of the flotation plant the Le Roi No. 2 has been sending regular shipments of concentrate to the Trail smelter, so it is likely, now that Mr. Cunningham has relinquished his option, the London company will operate the mine itself. Douglas Lay, who is managing Le Roi No. 2, at one time was manager of the Van Roi mine.

Dolly Varden.—The Taylor Mining Co. has reopened the Dolly Varden mine and the 18 miles of railway connecting the mine with tide-water at Alice Arm. Though work will be confined principally to development, it is expected that some 4,000 tons or ore will be shipped to the Granby smelter at Anyox before snow closes the railway again for the winter. This generally happens about the first week in December. About thirty men have been taken on the payroll, and when the railway is closed half of these will be transferred to the Wolf mine, also owned by the Taylor company, and

development is to be continued at both mines throughout the winter. One of the compressors is being moved from the Dolly Varden to the Wolf, and the hydro-electric power station that was constructed last year will operate all the machinery at both mines.

ATLIN GOLD MINES.—The action of the Engineer Mining Co. against J. A. Fraser, administrator of the estate of James Alexander, involving the ownership of the Engineer mine at Atlin, one of the richest lode-gold mines in the Province, has been decided in favour of the Alexander estate, the judge ruling that the action had been too long delayed, and should have been brought during the life of the late Captain Alexander. The plaintiff company claimed that Captain Alexander and his associates jumped the claims and eventually obtained Crown grants to them. The company claims to have expended $40,000 on the property. Be this as it may, Captain Alexander operated the property for a number of years and took a considerable amount of gold from it by the crudest of appliances. The ore is rich nuggety gold ore, and much of the gold was recovered by crude crushing and revolving in a clean-up barrel with mercury. The Mining Corporation of Canada became interested in the property and sent engineers to examine it, and it was while returning from this examination that Captain Alexander, his wife, and the engineers lost their lives in the sinking of the *Princess Sophia*. Since that time the mine has been almost continuously in litigation. Notice has been given that the present decision is to be appealed.

MELBOURNE

September 6.

THE AUSTRALASIAN INSTITUTE.—The 1921 meeting of the Australasian Institute of Mining and Metallurgy commenced on Monday, August 22, at University Chambers, Sydney. Mr. G. C. Klug (Vice-President) occupied the chair, and in his opening remarks apologized for the unavoidable absence of the President (Professor Chapman). After the formal opening, the business meeting adjourned until 2 p.m., and members proceeded to the Mining Museum in George Street, where an inspection was made of the magnificent collection of rocks and minerals on view there.

During the day a conference was held to consider proposals to form an Engineering Council, composed of representatives from the three Federal Institutes, namely, the Institution of Engineers (Australia), the Australian Chemical Institute, and the Australasian Institute of Mining and Metallurgy. Messrs. G. C. Klug and A. S. Kenyon attended as representatives of the Institute; Dr. T. Cooksey and Mr. H. G. Smith representing the Australian Chemical Institute; Messrs. D. F. J. Harricks and G. A. Julius representing the Institution of Engineers, Australia. After a full discussion, the following resolutions were unanimously adopted :—

(1) That a Federal Council be formed by representatives of the Institution of Engineers (Australia), the Australian Chemical Institute, and the Australasian Institute of Mining and Metallurgy, hereinafter referred to as the constituent bodies, and that the name of the Council shall be "The Federal Engineering Council, Australia." Subject to the unanimous approval of the councils of all the constituent bodies, other Federal Technical Institutions may be admitted to membership.

(2) That the objects of the Council shall be to consider and act upon matters of common concern to the technical professions and to co-ordinate the activities of the bodies represented on all questions of national and general importance.

(3) That the Council shall consist of three representatives from each of the constituent bodies, such representatives to be elected annually.

(4) That the Council shall elect a president from among its members, and shall appoint such officers and make such rules for the conduct of its business as may be found necessary. The Council shall elect its president within one month of taking office.

(5) That the headquarters of the Council shall be Sydney.

(6) That the Council shall have no jurisdiction over the internal affairs of any constituent body, but its decision upon matters referred to it for decision by the whole of the constituent bodies shall be adopted by all such bodies.

(7) That the Council shall meet to deal with any question which may be referred to it by any constituent body, and in any case shall meet at least once annually. Where a representative is unable to attend any meeting of the Council the constituent body that he represents shall have power to appoint a substitute for that meeting.

(8) That notice of any question referred

to the Council by one of the constituent bodies must be forwarded to the secretary of each of the other constituent bodies at least one month before the meeting of the Council at which the question is to be discussed; this period may be varied only with the consent of all the constituent bodies.

(9) That the constituent bodies shall meet the cost of the Federal Council in equal proportions, and it is considered that the contribution should not exceed £25 per annum from each constituent body. The travelling expenses of delegates shall be met by their respective institutions.

(10) That any constituent body may withdraw from the Council by giving twelve months' notice, and after the expiry of that period it shall be relieved of all further obligations to the Council.

It was unanimously agreed that the three professional bodies represented at the conference be urged to take immediate action in the matter, so that the Federal Council may be formed at the beginning of the year 1922, and the chairman subsequently announced that the conference regarding the proposal had been very successful, and it was almost certain that a Federal Engineering Council would be constituted.

It was resolved that it be a recommendation to the Council of the Institute that the ordinary meeting for 1922 should be held at Port Pirie, South Australia. It was also mentioned that the Council was considering the practicability of holding the ordinary meeting for 1923 in New Zealand, so as to dovetail with the meeting of the Australasian Association for the Advancement of Science.

It was urged that the Institute should secure greater recognition by the Federal and State Governments. One of the principal reasons for obtaining this recognition was, it was urged, to prevent reports by incompetent persons being used for the flotation of mining and industrial companies. The chairman explained that the proposed Federal Council would, when constituted, be a power for good in this matter.

The papers presented for discussion were:

"Mechanical Methods for Allaying Dust." By P. H. Warren.

"The Artificial Ventilation of the Broken Hill Proprietary Mine." By R. T. Slee.

"Ventilation: Metalliferous Mines." By T. G. Hanton.

"A Proposed Copper Metallurgical Process." By P. Burbidge.

"The Use of Explosives in Steel Works." By R. T. Slee.

"Description of New Plant at South Mine, Broken Hill." By W. E. Wainwright and J. C. Cunningham.

"Determination of Minute Amounts of Lead in Water, with Notes on certain causes of Error." By D. Avery, A. J. Hemingway, and V. G. Anderson.

On Tuesday, the 23rd, the Institute excursion to Lithgow took place, and the visit was chiefly occupied in visiting the works of the Hoskins Iron and Steel Co. The business is owned and operated by Mr. C. H. Hoskins and members of his family. The capital of the company is £2,500,000, and there are approximately 2,500 men employed at the present time, but with the extensions that are contemplated in the near future this number will be considerably increased. The various plants operated by the company are as follows:—

The main iron and steel works are situated at Lithgow, on the Blue Mountains, 96 miles west of Sydney, at an elevation of 3,000 ft. above sea level. An engineering and cast-iron pipe works are situated at Sydney, and Rhodes, a suburb of Sydney. A colliery comprising 5,000 acres of coal land, together with coking plant is situated at Dapto, on the coast, 56 miles south of Sydney in the southern coalfield.

The company has recently purchased 400 acres of land on the coast at Port Kembla, 8 miles distant from the above colliery and coking plant, with a view to establishing a modern steel works to allow for future extensions whenever required. One of the directors has just returned from an extensive tour of England, the United States, and Canada, where he gathered information regarding the most modern iron and steel plants, in order that the new plant on the coast, together with numerous alterations and extensions to the existing plant at Lithgow, should be along the most modern lines.

The company is practically self-supporting for all its raw materials, as it owns numerous iron ore properties in New South Wales and Tasmania, together with extensive coal properties and limestone deposits.

In addition to the above they also own several manganese ore properties, containing ore of very high quality, from which many thousands of tons of high-grade ferro-manganese have been produced during the past five years.

The company holds numerous iron ore properties, which together are estimated to contain between 80,000,000 and 100,000,000 tons of good ore. The ore for the present steelworks at Lithgow is drawn from Tallawang, 100 miles north-west; Carcoar, 80 miles south-west; and Cadia, 100 miles south-west of Lithgow. The first-mentioned ore is a magnetite, containing 60% of iron; the latter two deposits are red hematite, containing 57–58% of iron. Numerous other deposits are also held about 100 miles south-west and south of Lithgow.

PERSONAL

W. J. BARNETT is on a visit to British Columbia, where he is examining alluvial gold properties.

JOHN A. BEVAN left last month for Roumania.

C. W. BOISE has returned from a visit to the Akim diamond fields, West Africa.

SIR ROBERT BORDEN, recently Premier of Canada, has been elected a director of the British America Nickel Corporation.

VICARS W. BOYLE has returned from Nigeria.

J. E. BREAKELL is expected from West Africa.

C. V. CORLESS, manager of the Mond Nickel Co.'s mines, has returned to Canada after a brief visit to England.

W. DEMPSTER has gone to Kamptee, Central Provinces, India.

J. B. DENNISON has left for Mexico.

G. A. HARRISON has returned from Roumania.

HARLEY E. HOOPER has joined the staff of the Department of Mining in the Melbourne Technical School.

ERLE HUNTLEY has been appointed general manager of the Laloki copper mines, Papua.

DUDLEY J. INSKIP leaves for South Africa on the 23rd.

LIONEL LINDSAY was married to Miss Kathleen Yone Kennedy on October 25 at St. Peter's, Cranley Gardens, South Kensington.

M. C. H. LITTLE is here from Italy.

BERNARD MACDONALD has opened an office at Parral, Mexico, as consulting mining engineer.

C. T. MADIGAN has been appointed lecturer on geology in the Adelaide University, as assistant to Sir Douglas Mawson.

E. MAXWELL-LEFROY has returned to Burma from a tour in Australia, New Zealand, Java, and the Malay Peninsula.

J. Q. MITCHELL left on October 19 for West Africa.

W. A. POPE has returned from Nigeria.

R. W. PRINGLE is examining the Umvukwe chrome deposits, Rhodesia.

G. E. STEPHENSON is home from New Zealand.

D. A. THOMSON is here from West Africa.

DR. R. C. WALLACE has resigned as Commissioner of Northern Manitoba, and has returned to his position at the University of Manitoba.

LOUIS A. WRIGHT has left Italy and expects to return to the United States about December 1.

B. RANCE, the chief engineer to the Burma Ruby Mines, Ltd., died last month.

JOSEPH W. RICHARDS, professor of metallurgy in the Lehigh University, died on October 12 in his 58th year. He was well known on this side as author of the books *Aluminium* and *Metallurgical Calculations*.

CHARLES W. WHITLEY, vice-president of the American Smelting & Refining Co., died on October 9, aged 50. He was for some years well known as the representative of this company at Salt Lake City.

DR. WILLIAM SPEIRS BRUCE died at Edinburgh on October 31 after a long illness, at the age of 54. He was one of our foremost explorers in the Arctic and Antarctic regions, and his contributions to the geology of Spitsbergen are well known to our readers.

TRADE PARAGRAPHS

THE WESTINGHOUSE ELECTRIC INTERNATIONAL COMPANY, of East Pittsburgh, and 2, Norfolk Street, Strand, London, W.C. 2, send us particulars of their Midget Storage Battery Locomotive.

HYATT, LTD., of Thurloe Place, South Kensington, London, S.W. 7, send us a copy of their new sectional catalogue dealing with the application of Hyatt Roller Bearings to colliery tubs and mine cars.

G. A. HARVEY & CO. (LONDON), LTD., of Woolwich Road, London, S.E. 7, send us new lists of a great variety of their manufactures: screens of all kinds for mines and quarries, oil-storage tanks, steel ventilating pipes, steel hoppers, etc.

RUSTON AND HORNSBY, LTD., of Lincoln, will be well represented at the Public Works, Roads, and Transport Exhibition to be held at the Agricultural Hall, London, from November 17 to 25. They will make a special show of their excavators and road rollers.

THE METROPOLITAN-VICKERS ELECTRICAL CO., LTD., of Trafford Park, Manchester, and 4, Central Buildings, Westminster, send us their pamphlet 7,855/2, relating to the choice of motors for industrial work; also a leaflet dealing with their Cosmos vacuum and gas-filled incandescent electric lamps.

THE HARDINGE COMPANY, of 120, Broadway, New York, and 11, Southampton Row, London, W.C. 2, send us their new catalogue, No. 9, dealing with pulverized fuels. Particulars are given of the application of the Hardinge conical mill to the production of pulverized coal, which nowadays has so many important applications.

EDGAR ALLEN & CO., LTD., of the Imperial Steel Works, Sheffield, send us their new pamphlet relating to carbon tool steels. This pamphlet gives practical hints on points deciding when it is economical to use carbon tool steels, and gives full working instructions, together with many tables and details bearing on this subject.

T. COOKE & SONS, LTD., of the Buckingham Works, York, and 3, Broadway, Westminster, send us their new catalogue of surveying instruments. This catalogue is of particular value to the mining engineer, as it not only contains a description of a great variety of old and new instruments, but gives full descriptions of all the novelties, and scientific explanations of new principles.

HADFIELDS, LTD., of the East Hecla Works, Tinsley, Sheffield, will be well represented at the Public Works, Roads, and Transport Exhibition at the Agricultural Hall, Islington, which will be open from November 17 to 25. This firm supply much plant and machinery used for traction on roads,

such as manganese steel rails, tyres, axles, etc. Their machinery is also of great value in the preparation of paving materials, their breakers and crushers being in general use for the production of both macadam and smaller material.

HOLMAN BROTHERS, LTD., of Camborne, send us a new pamphlet describing their Type 3 drill-sharpener. This pamphlet gives full details of the operation of this important adjunct to mine plant, with particulars of its special advantages and method of using. They also send us a pamphlet on their tools and plant suitable for colliery equipment, namely, haulages, air-compressors, coal-washers, coal cutters, coal picks, and rock-drills. Other new pamphlets deal with the Holman-Taquah log saw and with china-clay plant.

JOHN & EDWIN WRIGHT, LTD., of the Universe Works, Birmingham, send us their list, No. 100, which deals with the cross-sections of a great variety of wire ropes, with explanations of their particular applications. They also send us their pocket instrument, called the "Caliper-Clinometer," which is intended for the measurement of the inclination of ropes and their diameter, and for the inside measurement of the pulley grooves. Reference is made to this instrument in the column devoted to Recent Patents Published, elsewhere in this issue.

HEAD, WRIGHTSON & CO., LTD., of Stockton-on-Tees, and 5, Victoria Street, Westminster, send us a leather case for the shelf containing a set of their new pamphlets relating to a number of their specialties, as follow: Headgears, cages, etc.; coal-screening and sorting plant; pulley-blocks and hoists; steel chimneys and tanks; blast-furnace plant; Marcus screens and conveyors; Nissen stamp-mills; coal-shippers and hoists; Stanley cage props; Simplex air-locks; pit-cages; Lowden patent dryer; Colorado convertible discharge ball-mill; Akins classifier; Notanos patent rotary dryer; cement works plant; iron castings; and the King grinding pan.

THE CONSOLIDATED PNEUMATIC TOOL CO., LTD., of 170, Piccadilly, London, W., send us particulars of a new type of electric hammer, adapted for both stone and iron work, which they are now introducing. A practical electric hammer has been the object of much investigation. The firm can safely claim to have achieved a result which will satisfy the discriminating user. The stone hammer is suitable for nearly all classes of stone working, and gives excellent results when used for carving, channelling, and large lettering work. Trials have demonstrated that it does the work about four or five times faster than hand labour, with much more satisfactory results, owing to ease of control and convenience of the tool. The weight is 5 lb., and the overall length 11½ inches. The light riveting and chipping hammer has been through long and severe tests, and the results obtained are thoroughly satisfactory. In addition to the foregoing uses, this electric hammer makes an efficient tool for drilling holes through concrete, stone, or brickwork when fitted with suitable bits. It has already been used for this purpose with very satisfactory results. The weight is 7 lb., and the overall length 13½ inches.

THE WESTINGHOUSE ELECTRIC & MANUFACTURING CO., of East Pittsburgh, Pennsylvania, send us particulars of the contract they have secured for the supply of the equipment to electrify the Chilean State Railway between Valparaiso and Santiago, and the Los Andes branch. This contract covers the most important railway electrification undertaken since the beginning of the war, and the largest ever undertaken by an American firm outside of the United States. The main line, which is 116 miles long, is now under steam operation, and is the most important railway line in Chile. It connects the leading seaport (Valparaiso) with the capital (Santiago), while the line to Los Andes is 28 miles long and forms the Chilean State Railway section of the trans-continental line to Buenos Aires. The equipment to be furnished consists of eleven local passenger locomotives, fifteen road freight locomotives, seven switching engines, and five sub-stations of 4,000 k.w. capacity each. The 3,000 volt direct current system will be used and will be of American character. Owing to the abundance of water power in Chile, and the high price of fuel, all of the Chilean railroads will eventually be electrified, and the present project is the first step in this process.

METAL MARKETS

COPPER.—The standard copper market in London kept fairly firm until towards the middle of October, when prices tended to recede. The firmness at the beginning of the month was partially, at least, due to the rise in the price of electrolytic in New York, where 13 cents was touched. There appeared to be a little increase in American consuming demand, which might have justified a small rise in the cent price, but the suspicion was current on the London market that the movement was more or less artificial. In the meantime, the German mark began to fall to unprecedented levels, with the result that purchases by that country in America had to be restricted. An immediate consequence was a weaker tone on the New York market, which was sympathetically reflected in London values. Whatever may be said of the ultimate future, there certainly seems little to encourage purchasers at the moment. Consuming demand in this country can only be described as unsatisfactory, while Continental inquiry, though at times moderate, has suffered from the adverse exchanges. In the United Kingdom stocks of standard are gradually increasing, and seem likely to continue doing so owing to the warehousing of old metal which has been converted into rough copper. Meanwhile, despite drastically curtailed output in the United States, the large stocks in existence there prevent the curtailment in production being felt.

Average price of cash standard copper: October, 1921, £67 8s. 1d.; September, 1921, £68 0s. 11d.; October, 1920, £93 10s. 1d.; September, 1920, £96 13s. 4d.

TIN.—Values on the standard market in London fluctuated somewhat during October, but on balance prices were practically unaltered on the month. The statistics published at the end of September, indicating a substantial increase in the visible supplies of tin, had little adverse effect on values, probably because it was felt that the present low quotation discounts most of the adverse factors. A favourable feature during the month was the improving demand from the British and American tinplate works. The real malady of the tin-producing industry is under-consumption rather than over-production, and any broadening of genuine demand is therefore to be welcomed. Continental demand was on a moderate scale, though the weakness in the mark curtailed German

Daily London Metal Prices: Official Closing
Copper, Lead, Zinc, and Tin per Long Ton

	Copper				
	Standard Cash	Standard (3 mos.)	Electrolytic	Wire Bars	Best Selected
Oct.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.
11	69 7 6 to 69 10 0	70 7 6 to 70 10 0	75 10 0 to 77 10 0	75 10 0 to 77 10 0	70 0 0 to 71 10 0
12	69 5 0 to 69 10 0	70 5 0 to 70 10 0	75 10 0 to 77 10 0	76 10 0 to 77 10 0	— —
13	68 7 6 to 68 10 0	69 10 0 to 69 12 6	75 10 0 to 77 10 0	76 10 0 to 77 10 0	— —
14	67 12 6 to 67 15 0	68 15 0 to 68 17 6	74 10 0 to 76 10 0	75 10 0 to 76 10 0	68 10 0 to 70 10 0
17	66 7 6 to 66 10 0	67 12 6 to 67 15 0	74 0 0 to 76 0 0	75 0 0 to 76 0 0	— —
18	65 15 0 to 66 0 0	67 0 0 to 67 5 0	73 0 0 to 75 0 0	74 0 0 to 75 0 0	66 0 0 to 68 0 0
19	66 2 6 to 66 7 6	67 5 0 to 67 10 0	73 0 0 to 75 0 0	74 0 0 to 75 0 0	— —
20	66 5 0 to 66 10 0	67 10 0 to 67 12 6	73 0 0 to 75 0 0	74 0 0 to 75 0 0	— —
21	66 0 0 to 66 2 6	67 2 6 to 67 5 0	73 0 0 to 75 0 0	74 0 0 to 75 0 0	67 0 0 to 69 0 0
24	66 2 6 to 66 5 0	67 2 6 to 67 5 0	72 10 0 to 74 10 0	73 10 0 to 74 10 0	— —
25	66 0 0 to 66 2 6	67 0 0 to 67 2 6	72 10 0 to 74 10 0	73 10 0 to 74 10 0	66 10 0 to 68 0 0
26	65 5 0 to 65 7 6	66 5 0 to 66 7 6	72 0 0 to 74 0 0	73 0 0 to 74 0 0	— —
27	65 10 0 to 65 12 6	66 12 6 to 66 15 0	72 0 0 to 74 0 0	73 0 0 to 74 0 0	— —
28	65 15 0 to 65 17 6	66 15 0 to 66 17 6	72 0 0 to 74 0 0	73 0 0 to 74 0 0	66 0 0 to 68 0 0
31	66 2 6 to 66 5 0	67 0 0 to 67 5 0	72 10 0 to 74 10 0	74 0 0 to 74 10 0	— —
Nov.					
1	66 5 0 to 66 7 6	67 2 6 to 67 5 0	73 0 0 to 75 0 0	74 0 0 to 75 0 0	66 15 0 to 68 15 0
2	67 0 0 to 67 2 6	67 7 6 to 67 10 0	73 10 0 to 75 10 0	74 10 0 to 75 10 0	to
3	66 15 0 to 66 17 6	67 5 0 to 67 7 6	73 10 0 to 75 10 0	74 10 0 to 75 10 0	- to
4	66 15 0 to 66 17 6	67 2 6 to 67 5 0	73 10 0 to 75 10 0	74 10 0 to 75 10 0	67 0 0 to 69 0 0
7	65 17 6 to 66 0 0	66 10 0 to 66 12 6	73 10 0 to 75 10 0	74 10 0 to 75 10 0	to
8	66 5 0 to 66 7 6	66 15 0 to 66 17 6	73 0 0 to 75 0 0	74 0 0 to 75 0 0	66 10 0 to 68 10 0
9	66 0 0 to 66 2 6	66 12 6 to 66 15 0	73 0 0 to 75 0 0	74 0 0 to 75 0 0	— —

purchases. America, on the whole, bought little, the rising tendency in sterling being partly responsible. The Straits sold pretty freely during the month, and a feature was the arrival of good lines of Banca tin in this country. Stocks in the United Kingdom are increasing, while the Federated Malay States Government has still to find a favourable opportunity of disposing of its large holding. There are indications that production in the Federated Malay States and Batavia is to be cut shortly, and unless consumption increases this appears inevitable. Output in Nigeria, Bolivia, and Cornwall continues to be drastically curtailed, and should a serious restriction in the East take place, the general position might inspire more confidence than seems at present justified.

Average price of cash standard tin: October, 1921, £156 10s.; September, 1921, £156 17s. 6d.; October, 1920, £258 8s. 8d.; September, 1920, £270 7s. 3d.

Lead.—Steadiness was the chief characteristic of the London lead market last month, and prices underwent very little alteration, although they closed slightly higher on balance. Demand from English consumers tended to decline, but this was compensated for during the first half of the month by an active inquiry from Germany. The subsequent decline in the mark, however, compelled German buyers to restrict their purchases, and but for the firm attitude of holders, prices might well have weakened. Arrivals of fresh metal continued scanty and erratic, and dealers and consumers, unable to obtain delivery of shipment lead owing to steamer-discharging delays, were compelled to cover their requirements by purchasing ex-warehouse. This, coupled with consumers' general policy of buying only for immediate delivery, maintained the premium on early delivery metal. In the United States the market was firm, thanks to a good domestic demand. British dealers encountered fairly stiff competition on the Continent from American interests, although no offers were made on the London market. Some Burmese and Australian metal came forward during the month, but not in sufficient quantities to compensate for the shortage of Spanish lead; the outlook, however, seems favourable towards larger arrivals from the two first-named countries in the near future. As regards Mexico, the position there seems to be improving, but no metal has so far come out on the London market.

Average price of soft pig lead: October, 1921, £23 10s. 8d.; September, 1921, £22 19s. 5d.; October, 1920, £35 2s. 1d.; September, 1920, £35 7s. 6d.

Spelter.—Values on the London spelter market underwent little change during October, although sentiment was inclined to be changeable. At one time values tended to ease off, owing to fears of larger offerings from Germany in consequence of the weakness of the mark, but the non-realization of such apprehensions infused a little more confidence. An encouraging factor during the month was the continuance of the improved demand from British galvanizers. Producing countries were very reserved in their attitude, and very little metal was offered by either Belgium, Norway, or Germany. Some French spelter, however, was sold to this country, having possibly been set free by arrivals of spelter from Germany under the Wiesbaden agreement. The situation in Upper Silesia must continue to affect the market position to some extent; under the League of Nations' frontier decision, all the spelter works and nearly all the zinc mines are granted to Poland. German stocks are believed now to be of fairly manageable proportions, while Belgium, whose production is steady around 5,000 monthly, does not seem to have much metal to spare. In the United States the market has been firm, with a fair demand, and stocks are trending downwards. There appear to be good prospects of a resumption being made shortly in the English spelter industry, the Board of Trade having arranged for supplies of Australian zinc concentrates. Towards the end of the month the demand from galvanizers became less pressing and values eased slightly.

PRICES ON THE LONDON METAL EXCHANGE.
Silver per Standard Ounce; Gold per Fine Ounce.

Lead: Soft Foreign	Lead: English	Zinc (Spelter)	Standard Tin: Cash	Standard Tin: 3 mos.	Silver: Cash	Silver: Forward	Gold	
£ s. d. £ s. d.	£ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	d.	d.	s. d.	Oct.
23 5 0 to 23 0 0	24 10 0	26 12 6 to 27 0 0	155 12 6 to 155 17 6	158 2 6 to 158 7 6	42½	42⅛	106 8	11
23 10 0 to 23 5 0	24 10 0	26 12 6 to 27 0 0	155 15 0 to 156 0 0	158 5 0 to 158 10 0	42⅝	42⅜	—	12
23 17 6 to 23 10 0	24 15 0	26 12 6 to 27 0 0	155 10 0 to 155 15 0	157 17 6 to 158 0 0	42⅞	42⅝	107 2	13
23 17 6 to 23 10 0	24 15 0	26 10 0 to 26 17 6	155 5 0 to 155 10 0	157 12 6 to 157 15 0	42⅜	42⅛	106 5	14
23 17 6 to 23 10 0	24 15 0	26 2 6 to 26 10 0	157 10 0 to 157 15 0	159 15 0 to 160 0 0	42⅛	42	105 4	17
23 15 0 to 23 7 6	24 15 0	26 2 6 to 26 10 0	157 5 0 to 157 10 0	159 10 0 to 159 15 0	40⅝	40⅜	104 1	18
23 15 0 to 23 7 6	24 15 0	26 2 6 to 26 10 0	156 15 0 to 157 0 0	159 0 0 to 159 5 0	39⅞	39⅝	105 7	19
23 15 0 to 23 7 6	24 15 0	26 7 6 to 26 15 0	157 5 0 to 157 10 0	159 12 6 to 159 15 0	40⅞	40⅛	104 9	20
24 0 0 to 23 15 0	25 0 0	26 7 6 to 26 15 0	158 5 0 to 158 10 0	160 10 0 to 160 15 0	40⅞	40½	104 0	21
24 2 6 to 23 15 0	25 0 0	26 5 0 to 26 10 0	158 0 0 to 158 5 0	160 10 0 to 160 15 0	40⅛	39¾	104 8	24
24 2 6 to 23 17 6	25 0 0	25 17 6 to 26 5 0	156 10 0 to 156 15 0	158 15 0 to 159 0 0	39⅛	38¾	104 4	25
24 2 6 to 23 15 0	25 0 0	25 15 0 to 26 5 0	155 10 0 to 155 15 0	158 0 0 to 158 5 0	39⅝	39¼	104 2	26
24 0 0 to 23 12 6	25 0 0	25 17 6 to 26 7 6	156 10 0 to 156 15 0	158 17 6 to 159 0 0	40	39⅛	104 5	27
24 0 0 to 23 15 0	25 0 0	25 17 6 to 26 10 0	156 0 0 to 156 5 0	158 5 0 to 158 10 0	40⅞	40¼	104 10	28
24 0 0 to 22 12 6	25 0 0	26 0 0 to 26 10 0	156 10 0 to 156 15 0	158 15 0 to 158 17 6	40¾	39⅞	104 9	31
								Nov.
23 17 6 to 23 10 0	25 0 0	26 2 6 to 26 12 6	155 10 0 to 155 15 0	157 15 0 to 158 0 0	40⅛	39⅜	104 9	1
23 12 6 to 23 7 6	24 15 0	26 0 0 to 26 12 6	155 0 0 to 155 5 0	157 5 0 to 157 10 0	40½	39⅞	104 10	2
23 12 6 to 23 7 6	24 15 0	25 17 6 to 26 10 0	155 5 0 to 155 10 0	157 10 0 to 157 15 0	40¼	39⅝	104 7	3
23 12 6 to 23 7 6	24 15 0	25 17 6 to 26 10 0	156 15 0 to 157 0 0	158 10 0 to 158 15 0	39⅞	39⅜	104 4	4
23 15 0 to 23 7 6	24 15 0	25 17 6 to 26 10 0	158 10 0 to 158 15 0	160 0 0 to 160 5 0	39	38⅝	104 4	7
23 15 0 to 23 7 6	24 15 0	25 15 0 to 26 7 6	158 10 0 to 158 15 0	160 10 0 to 160 15 0	39⅜	39	104 3	8
23 17 6 to 23 10 0	25 0 0	25 10 0 to 26 5 0	157 5 0 to 157 10 0	159 5 0 to 159 5 0	38¾	38⅜	104 2	9

Average price of spelter: October, 1921, £26 10s. 7d.; September, 1921, £26 10s. 8d.; October, 1920, £40 5s. 6d.; September, 1920, £40 5s. 6d.

ZINC DUST.—Rather more inquiry is reported. Prices are slightly easier on the month: Australian high-grade £50, American 92 to 94% £47 10s., and English 92 to 94% £45.

ANTIMONY.—Values are lower, as follows: English regulus, ordinary grades, £35 to £38, special brands £36 5s. to £40, and 98 to 99% £25 to £28. Foreign is about £24 10s.

ARSENIC.—Cornish white is nominal at about £40 per ton, f.o.r. Cornwall.

BISMUTH.—The price is steady at 7s. 6d. per lb.

CADMIUM.—The market is quiet and the quotation unchanged at 6s. per lb.

ALUMINIUM.—There is no change to report. Domestic producers quote £120 for home and £125 for export business, while foreign metal is still offering around £100 f.o.b. Continent.

NICKEL.—Producers here are nominally asking £190 for home and export, but foreign metal is obtainable at well below this.

COBALT METAL.—Inquiry is quiet, but the price is unchanged at 14s. per lb.

COBALT OXIDE.—There is not much business passing. Black oxide is priced at 10s. 9d. and grey at 12s. per lb.

PLATINUM AND PALLADIUM.—Manufactured platinum is quoted at £20 5s. and raw metal at £18 per oz. Palladium is unchanged, with manufactured at £18 to £20 and raw at £14 to £15 per oz.

QUICKSILVER.—At the moment the market is steady, though business is only moderate. The price is £9 10s. to £9 12s. 6d. per bottle.

SELENIUM.—Powder is quoted at 9s. 6d. per lb.

TELLURIUM.—The quotation is lower at 70s. to 80s. per lb.

SULPHATE OF COPPER.—Values are easier at £28 to £30 per ton, for both home and export business.

MANGANESE ORE.—The price has fluctuated, but is lower on the month at 1s. 2d. c.i.f.

TUNGSTEN ORE.—Business is quiet, and the quotation steady at 12s. 6d. to 13s. c.i.f. for 65% WO_3.

MOLYBDENITE.—The price of 85% is steady at 37s. 6d. to 40s. c.i.f., nominal.

CHROME ORES.—The market is idle, the quotation being lower on the month at £4 to £4 5s. c.i.f.

SILVER.—Values receded during the month on balance, despite an upward reaction towards the close, owing to steady selling by India. The market received some support from Chinese purchasers. On October 1 spot bars were quoted at 42⅜d., eased to 41¼d. on the 6th, firmed up to 42⅜d. on the 8th, and after falling to 42¼d. on the 10th, rose to 42⅞d. on the 13th. By the 19th the price was down to 39⅞d., followed by 40⅞d. on the 20th and 39⅛d. on the 25th. Some support then pushed the price up to 41⅛d. on the 29th, but the quotation closed lower on the 31st at 40¾d.

GRAPHITE.—Business is quiet and values nominal Sellers still quote Madagascar, 80 to 90%, at £20 to £25 per ton c.i.f.

IRON AND STEEL.—The recovery in the iron and steel trades is proceeding at a slow rate, and the number of blast-furnaces in operation is being increased only gradually. Pig iron prices have been reduced, however, in the hopes of attracting buyers. No. 3 Cleveland is now quoted at 110s. for the home trade, whilst 115s. is asked for export. The Continent is still in a position to undercut for shipment business. Hematite is weak, and worth scarcely more than 120s. A few small parcels have been going into home consumption, but export trade is practically stagnant. In the finished departments, a big effort has been made to stimulate trade by cutting prices, and home trade quotations are roughly £3 down at £10 section basis. So far, however, it has had little effect. Export business is slow in spite of repeated reductions, and the Continent is still able to secure the cream of the export business. If costs came down to a reasonable level, British makers would undoubtedly come into their own again, for many schemes are being held up until preference can be given to our home works.

STATISTICS

PRODUCTION OF GOLD IN THE TRANSVAAL.

	Rand	Elsewhere	Total	Price of
	Oz.	Oz.	Oz.	Gold per oz.
				s. d.
September, 1920	666,486	15,687	682,173	115 0
October	645,819	16,653	662,472	117 6
November	618,525	15,212	633,737	117 6
December	617,549	14,666	632,215	115 0
Total, 1920	7,949,038	204,587	8,153,625	—
January, 1921	637,425	14,168	651,593	105 0
February	573,767	14,370	588,137	103 9
March	656,572	14,551	671,123	103 9
April	665,309	16,073	681,382	103 9
May	671,750	16,026	687,776	103 9
June	663,383	15,107	678,490	107 6
July	673,475	16,080	689,555	112 6
August	695,230	16,296	711,526	111 6
September	674,157	16,939	691,096	110 0

NATIVES EMPLOYED IN THE TRANSVAAL MINES.

	Gold mines	Coal mines	Diamond mines	Total
September 30, 1920	163,132	13,716	4,323	181,171
October 31	159,426	13,858	4,214	177,498
November 30	158,773	14,245	3,504	176,522
December 31	159,671	14,263	3,340	177,274
January 31, 1921	165,287	14,541	3,319	183,147
February 28	171,518	14,697	1,612	187,827
March 31	174,364	14,906	1,364	190,634
April 30	172,826	14,908	1,316	189,050
May 31	170,595	14,510	1,302	186,407
June 30	168,152	14,704	1,317	184,173
July 31	166,999	14,688	1,246	182,933
August 31	169,008	14,446	1,207	184,661
September 30	171,912	14,244	1,219	187,375

COST AND PROFIT ON THE RAND.

Compiled from official statistics published by the Transvaal Chamber of Mines.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
Sept., 1920	1,950,410	38 11	25 6	13 5	1,276,369
October	1,871,140	39 9	26 1	13 8	1,278,385
November	1,799,710	40 2	26 3	13 1	1,255,749
December	1,797,970	39 11	26 8	13 3	1,193,672
January, 1921	1,805,235	35 0	26 3	8 9	829,436
February	1,575,320	35 6	28 6	7 0	550,974
March	1,958,730	34 5	26 1	8 4	813,636
April	1,991,815	34 5	25 10	8 7	854,533
May	1,955,357	35 3	26 2	9 1	889,520
June	1,966,249	35 10	25 10	10 0	979,769
July	2,010,236	37 2	25 7	11 7	1,163,565
August	2,050,722	37 3	25 4	11 11	1,226,282

PRODUCTION OF GOLD IN RHODESIA.

	1919	1920	1921
	£	oz.	oz.
January	211,917	43,428	46,956
February	220,885	44,237	40,816
March	225,808	45,779	31,995
April	213,160	47,000	47,858
May	218,057	46,266	48,744
June	214,215	45,054	49,466
July	214,919	46,208	51,564
August	207,339	48,740	53,200
September	223,719	45,471	52,436
October	204,184	47,342	—
November	186,462	46,782	—
December	158,835	46,190	—
Total	2,499,498	552,498	429,035

TRANSVAAL GOLD OUTPUTS.

	August		September	
	Treated Tons	Yield Oz.	Treated Tons	Yield Oz.
Aurora West	11,050	£16,100*	10,800	£15,145†
Brakpan	58,600	22,578	57,500	22,113
City Deep	90,000	37,664	89,000	35,729
Cons. Langlaagte	44,000	£72,502*	44,000	£72,037†
Cons. Main Reef	48,000	18,058	50,000	17,719
Crown Mines	196,000	57,829	193,000	58,984
D'rb'n Roodepoort Deep	27,600	9,608	24,350	9,502
East Rand P.M.	126,500	33,390	124,000	33,652
Ferreira Deep	34,500	11,328	32,200	10,296
Geduld	44,500	15,621	45,000	16,185
Geldenhuis Deep	50,697	13,593	49,526	12,686
Glynn's Lydenburg	3,446	£7,124‡	3,675	£7,162§
Goch	17,500	£21,390*	17,100	£20,280†
Government G.M. Areas	145,000	£327,665*	140,000	£318,760†
Kleinfontein	50,900	13,679	49,700	13,017
Knight Central	29,200	7,228	28,600	6,761
Langlaagte Estate	41,300	£70,320*	41,600	£68,912†
Luipaard's Vlei	22,515	£28,265*	22,200	£27,020†
Meyer & Charlton	14,500	£45,544*	13,200	£42,180†
Modderfontein	100,000	48,114	101,000	46,994
Modderfontein B	60,000	31,452	59,000	30,736
Modderfontein Deep	44,400	24,818	43,000	23,355
Modderfontein East	27,300	12,316	25,000	9,791
New Unified	11,500	£13,892*	10,900	£13,958†
Nourse	45,000	14,688	41,200	15,062
Primrose	22,800	£27,927*	20,700	£25,715†
Randfontein Central	135,500	£218,405*	130,000	£202,792†
Robinson	40,000	7,629	40,000	7,701
Robinson Deep	61,600	17,871	63,600	18,486
Roodepoort United	23,000	£24,931*	22,600	£23,188†
Rose Deep	56,200	13,441	54,000	13,676
Simmer & Jack	53,700	13,772	55,200	13,298
Springs	41,500	18,179	36,250	16,075
Sub Nigel	10,200	5,491	10,200	5,513
Transvaal G.M. Estates	15,600	£27,271‡	15,445	£27,998§
Van Ryn	33,400	£53,016*	31,630	£50,287†
Van Ryn Deep	55,300	£165,428*	46,400	£144,960†
Village Deep	50,000	16,496	48,100	15,308
West Rand Consolidated	32,500	£49,909*	32,000	£48,092†
Witw'tersr'nd (Knights)	41,300	£58,779*	40,000	£56,758†
Witwatersrand Deep	31,060	9,423	33,630	9,717
Wolhuter	32,300	8,217	32,200	7,939

* Gold at £5 11s. 6d. per oz. † £5 10s. per oz. ‡ £5 9s. 9d. per oz. § £5 8s. 3d. per oz.

RHODESIAN GOLD OUTPUTS.

	August		September.	
	Tons	Oz.	Tons	Oz.
Cam & Motor	13,000	4,355	13,900	£24,501‡
Falcon	16,024	3,346‖	15,419	2,672*
Gaika	3,788	1,323	4,098	1,373
Globe & Phœnix	6,268	5,817	6,013	6,304
Jumbo	1,580	476	1,300	504
London & Rhodesian	2,473	£3,054	2,473	£3,054
Lonely Reef	5,170	4,901	4,950	4,418
Planet-Arcturus	5,600	2,495	5,700	2,611
Rezende	5,800	2,650	5,700	2,607
Rhodesia G.M. & I.	307	355	270	305
Shamva	53,750	£42,669§	55,300	£42,945‡
Transvaal & Rhodesian	1,450	£4,641†	1,620	£4,981†

* Also 255 tons copper. † At par. ‖ Also 270 tons copper § Gold at £5 10s. per oz. ‡ Gold at £5 5s. per oz.

WEST AFRICAN GOLD OUTPUTS.

	August		September	
	Treated	Value	Treated	Value
	Tons	Oz.	Tons	Oz.
Abbontiakoon	8,000	£13,853*	6,825	£13,395*
Abosso	6,239	2,496	6,397	2,596
Akoko	—	—	—	—
Ashanti Goldfields	7,356	7,760	7,685	7,263
Obbuassi	800	£3,440†	695	£3,117†
Prestea Block A	8,094	£15,367*	8,122	£14,594*
Taquah	3,340	2,065	3,390	2,097

* At par. † Including premium.

West Australian Gold Statistics.—Par Values.

	Reported for Export Oz.	Delivered to Mint Oz.	Total Oz.	Par Value £
January, 1921	523	50,934	51,457	218,574
February	684	26,872	27,556	117,050
March............	10	47,875	47,885	203,401
April	607	46,602	47,209	200,635
May	474	47,638	51,503	217,495
June.............	153	28,194	28,347	120,410
July	1,641	44,917	46,558	197,774
August..........	110	51,731	51,841	220,205
September.......	380	50,728	51,108	217,092
October	1,910	51,286	53,196	225,959

Australian Gold Outputs.

	West Australia	Victoria	Queensland	New South Wales
1921	oz.	oz.	oz.	£
January .	51,458	4,587	4,582	20,463
February.	27,557	10,940	9,046	21,575
March ...	47,886	12,383	6,690	24,344
April	47,273	5,954	2,501	34,101
May	48,113	10,280	2,077	15,356
June.....	28,347	10,431	1,602	11,640
July	55,207	5,528	1,531	16,416
August...	—	8,941	1,413	15,946
September	—	—	—	16,942
October .	—	—	—	—
November.	—	—	—	—
December	—	—	—	—
Total ..	206,841	69,047	29,532	176,983

Australasian Gold Outputs.

	August		September	
	Tons	Value £	Tons	Value £
Associated G.M. (W.A.)	6,217	8,313‖	5,789	7,512‖
Blackwater (N.Z.)	2,805	5,405*	3,159	6,372*
Gold'n Horseshoe (W.A)	10,512	5,483‡	10,128	5,325‡
Grt Boulder Pro. (W.A.)	9,438	29,494‖	8,312	27,014‖
Ivanhoe (W.A.)	16,126	6,185‡	14,804	6,041‡
Kalgurli (W.A.)	—	—	—	2,207*b*
Lake View & Star (W.A.)	6,765	15,791†‖	6,550	12,229†‖
Mount Boppy (N.S.W.)	4,405	1,111‡	—	—
Oroya Links (W.A.) ...	1,633	8,146†‖	1,541	7,618†‖
South Kalgurli (W.A.) .	7,862	12,700‖	7,610	13,532‖
Waihi (N.Z.)..........	14,197	4,480‡ 14,820§	4,236	3,540‡ 35,144§
,, Grand Junc'n (N.Z.)	6,380	1,499‡ 3,344§	6,280	1,771‡ 4,321§
Yuanmi (W.A.)	—	—	6,393	18,757**d*

* Including premium ; † Including royalties ; ‡ Oz. gold ; § Oz. silver ; ‖ At par. *b* Profit. *d* Four months.

Miscellaneous Gold and Silver Outputs.

	August		September	
	Tons	Value £	Tons	Value £
Brit. Plat. & Gold (C'lbia)	—	254§	—	283§
El Oro (Mexico)	34,700	196,000†	34,250	201,000†
Esperanza (Mexico)	—	300†‡	—	438†‡
Frontino & Bolivia (C'lbia)	2,160	8,608*	1,780	7,536*
Keeley Silver (Canada) ..	—	100,050§§	—	—
Mexico El Oro (Mexico)..	—	—	—	—
Mining Corp. of Canada .	8,435	132,521§§	—	—
Oriental Cons. (Korea) ...	16,433	76,055†	—	83,775†
Ouro Preto (Brazil)	7,100	2,370‖	6,500	2,375‖
Plym'th Cons. (Calif'rnia	8,200	6,913*	8,500	10,682*
St. John del Rey (Brazil).	—	43,000*	—	39,500*
Santa Gertrudis (Mexico)	29,762	16,227‡	29,817	17,000‡
Tomboy (Colorado)	18,000	69,000†	18,000	73,000†

* At par. † U.S. Dollars. ‡ Profit, gold and silver. ‖ Oz. gold. § Oz. platinum and gold. §§ Oz. silver.

Pato (Colombia) 8 days to September 21 $26,027 from 61,044 cu. yd.; 12 days to October 3, $30,515 from 90,260 cu. yd.; 18 days to October 21, $14,772 from 137,258 cu. yd.

Nechi (Colombia): 22 days to October 1, $19,649 from 177,358 cu. yd.; 10 days to October 11, $21,551 from 75,335 cu. yd.

Indian Gold Outputs.

	August		September	
	Tons Treated	Fine Ounces	Tons Treated	Fine Ounces
Balaghat	3,300	2,361	3,200	2,563
Champion Reef	12,127	4,822	11,650	4,848
Mysore...............	17,313	10,498	17,417	10,531
North Anantapur	700	904	700	898
Nundydroog	9,160	5,370	8,771	5,318
Ooregum	12,900	8,543	12,900	8,484

Production of Gold in India.

	1917	1918	1919	1920	1921
	Oz.	Oz.	Oz.	Oz.	Oz.
January	44,718	41,420	38,184	39,073	34,028
February ...	42,566	40,787	36,384	38,872	32,529
March	44,617	41,719	38,317	38,760	32,576
April	43,726	41,504	38,248	37,307	32,363
May........	42,901	40,889	38,608	38,191	32,656
June	42,924	41,264	38,359	37,864	32,207
July	42,273	40,229	38,549	37,129	32,278
August	42,591	40,496	37,850	37,375	32,498
September ..	43,207	40,088	36,813	35,497	32,642
October	43,041	39,472	37,138	35,023	—
November ..	42,915	36,984	39,628	34,522	—
December ..	44,883	40,149	42,643	34,919	—
Total ..	520,362	485,236	461,171	444,532	293,787

Base Metal Outputs.

		August	Sept.
Arizona Copper	Short tons copper ...	—	—
British Broken Hill ...	Tons lead conc. ...	—	—
	Tons zinc conc.	—	—
	Tons carbonate ore	—	—
Broken Hill Prop......	Tons lead conc. ...	—	1,117
	Tons zinc conc.	—	4,322
Broken Hill South	Tons lead conc.	2,935	2,949
Burma Corporation....	Tons refined lead ..	2,598	2,534
	Oz. refined silver ..	260,900	294,102
Hampden Cloncurry ..	Tons copper	—	—
	Oz. gold	—	—
Mount Lyell	Tons copper	470	602
	Oz. silver	14,056	20,152
	Oz. gold	342	412
Mount Morgan	Tons Copper	—	—
	Oz. gold	—	—
North Broken Hill.....	Tons lead conc......	1,200	1,200
	Tons zinc conc......	1,170	1,360
Pilbara	Tons copper ore	90	75
Rhodesia Broken Hill	Tons lead	1,569	1,431
Sulphide Corporation ..	Tons lead conc. ...	2,089	1,922
	Tons zinc conc	3,739	3,230
Tanganyika	Tons copper	2,952	2,783
Zinc Corporation	Tons zinc conc......	9,805	9,490
	Tons lead conc. ...	967	902

Imports of Ores, Metals, etc., into United Kingdom.

		August	September
Coal	Tons	167,133	20,194
Iron Ore	Tons	36,997	89,379
Manganese Ore	Tons	6,039	3,731
Copper and Iron Pyrites	Tons	16,375	19,520
Copper Ore, Matte, and Prec.	Tons	1,074	8,515
Copper Metal	Tons	8,317	5,760
Tin Concentrate	Tons	1,231	2,320
Tin Metal......................	Tons	2,086	1,974
Lead, Pig and Sheet	Tons	10,845	11,954
Zinc (Spelter)	Tons	3,907	4,480
Quicksilver	Lb.	112	7,800
Zinc Oxide....................	Tons	509	474
White Lead	Cwt.	2,705	4,344
Barytes, ground	Cwt.	28,714	32,892
Phosphate	Tons	15,697	42,249
Sulphur	Tons	—	—
Nitrate of Soda................	Cwt.	19,197	57,411
Petroleum			
Crude	Gallons	9,501,804	11,166,374
Lamp Oil	Gallons	9,784,263	8,068,040
Motor Spirit	Gallons	21,146,947	20,024,380
Lubricating Oil	Gallons	2,176,031	1,239,582
Gas Oil	Gallons	11,501,765	7,530,440
Fuel Oil	Gallons	52,422,202	46,421,748

Output of Tin Mining Companies.
In Tons of Concentrate.

	July	August	Sept.
	Tons	Tons	Tons
Nigeria:			
Associated Nigerian	—	—	—
Bisichi	35	36	40
Bongwelli	—	—	—
Champion (Nigeria)	—	—	—
Dua	—	—	—
Ex-Lands	20	—	30
Filani	—	6	6½
Gold Coast Consolidated	2½	2½	3
Gurum River	13	13	12
Jantar	—	—	—
Jos	5½	6	6½
Kaduna	13½	13½	17½
Kaduna Prospectors	7¼	7¼	12¼
Kano	—	—	—
Keffi Consolidated	23	—	21
Lower Bisichi	3½	4½	5½
Lucky Chance	—	—	—
Minna	—	—	—
Mongu	37	45	47½
Naraguta	50	50	50
Naraguta Extended	20	24	25
Nigerian Consolidated	8	9	7½
N.N. Bauchi	65	82½	83½
Offin River	—	—	—
Rayfield	37	26	24
Ropp	118	128	165
Rukuba	4	5	5
South Bukeru	16	—	13
Sybu	—	—	—
Tin Fields	8	11	14
Yarde Kerri	6	7	7
Federated Malay States:			
Chenderiang	—	—	75*
Gopeng	89	89	89
Idris Hydraulic	17¾	19¼	20¾
Ipoh	22	19¼	18
Kamunting	—	—	74*
Kinta	35¾	35¾	35¾
Labat	53½	43½	47½
Malayan Tin	86¼	83½	77½
Pahang	214	216	226
Rambutan	14	15	15½
Sungei Besi	47	48	46
Tekka	37	37	39
Tekka-Taiping	20	36	30
Tronoh	32	30	17
Cornwall:			
East Pool	—	—	—
Geevor	—	—	—
South Crofty	—	—	—
Other Countries:			
Aramayo Mines (Bolivia)	180	174	200
Berenguela (Bolivia)	28	28	32
Briseis (Tasmania)	—	10	13
Deebook Ronpibon (Siam)	23	21½	30
Leeuwpoort (Transvaal)	—	—	—
Macready (Swaziland)	—	—	—
Renong (Siam)	75	111	96½
Rooiberg Minerals (Transvaal)	50	50	50
Siamese Tin (Siam)	134½	121	102½
Tongkah Harbour (Siam)	123	113	84
Zaaiplaats (Transvaal)	—	—	—

* Three months.

Nigerian Tin Production.
In long tons of concentrate of unspecified content.

Note.—These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual outputs.

	1916	1917	1918	1919	1920	1921
	Tons	Tons	Tons	Tons	Tons	Tons
January	531	667	678	613	547	438
February	528	646	668	623	477	370
March	547	655	707	606	505	445
April	486	555	584	546	467	394
May	536	509	525	483	383	337
June	510	473	492	484	435	423
July	506	479	545	481	484	494
August	498	551	571	616	447	477
September	535	538	520	561	528	595
October	584	578	491	625	625	—
November	679	621	472	536	544	—
December	654	655	518	511	577	—
Total	6,594	6,927	6,771	6,685	6,022	3,953

Production of Tin in Federated Malay States.
Estimated at 70% of Concentrate shipped to Smelters. Long Tons.

	1917	1918	1919	1920	1921
	Tons	Tons	Tons	Tons	Tons
January	3,558	3,030	3,765	4,265	3,298
February	2,755	3,197	2,734	3,014	3,111
March	3,286	2,609	2,819	2,770	2,190
April	3,251	3,308	2,858	2,606	2,692
May	3,413	3,332	3,407	2,741	2,884
June	3,489	3,070	2,877	2,940	2,752
July	3,253	3,373	3,756	2,824	2,734
August	3,413	3,259	2,956	2,786	3,051
September	3,154	3,157	3,161	2,734	2,338
October	3,436	2,870	3,221	2,837	—
November	3,300	3,132	2,972	2,573	—
December	3,525	3,022	2,409	2,838	—
	39,833	37,370	36,935	34,928	25,050

Stocks of Tin.
Reported by A. Strauss & Co. Long Tons.

	Aug. 31	Sept. 30	Oct. 31
Straits and Australian Spot	1,811	1,748	2,168
Ditto, Landing and in Transit	590	510	966
Other Standard, Spot and Landing	3,994	4,226	5,194
Straits, Afloat	1,025	2,000	1,655
Australian, Afloat	190	190	175
Banca, in Holland	4,003	3,934	3,916
Ditto, Afloat	897	954	1,250
Billiton, Spot	327	241	126
Billiton, Afloat	100	130	63
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	650	425	840
Total Afloat for United States	3,689	4,663	4,497
Stock in America	1,761	1,756	2,041
Total	19,037	20,777	22,891

Shipments, Imports, Supply, and Consumption of Tin.
Reported by A. Strauss & Co. Long tons.

	August	Sept.	Oct.
Shipments from:			
Straits to U.K.	995	1,870	1,675
Straits to America	1,580	3,000	2,075
Straits to Continent	590	430	775
Straits to other places	950	615	475
Australia to U.K.	75	25	50
U.K. to America	490	390	210
Imports of Bolivian Tin into Europe	587	324	1,275
Supply:			
Straits	3,165	5,300	4,525
Australian	75	25	50
Billiton	275	100	63
Banca	966	1,085	1,975
Standard	928	811	290
Total	5,409	7,321	6,903
Consumption:			
U.K. Deliveries	2,004	1,707	1,808
Dutch ,,	389	329	255
American ,,	3,320	2,605	2,280
Straits, Banca & Billiton, Continental Ports, etc.	511	940	446
Total	6,224	5,581	4,879

OUTPUTS REPORTED BY OIL-PRODUCING COMPANIES.

		July	August	Sept.
Anglo-Egyptian	Tons	14,682	14,324	13,451
Anglo-United	Barrels	9,900	9,550	9,500
Apex Trinidad	Barrels	22,225	94,398	48,305
Astra Romana	Tons	22,234	27,013	—
British Burmah	Barrels	79,569	81,403	74,940
Caltex	Tons	13,340	13,340	—
Dacia Romana	Tons	236	305	278
Kern River	Barrels	93,421	96,061	97,118
Lobitos	Tons	9,323	9,109	8,631
Roumanian Consol	Tons	2,053	2,588	2,276
Santa Maria	Tons	1,371	1,286	—
Steaua Romana	Tons	18,730	22,760	19,485
Trinidad Leaseholds	Tons	18,892	11,800	10,950
United of Trinidad	Tons	2,983	4,291	5,700

QUOTATIONS OF OIL COMPANIES' SHARES.

Denomination of Shares £1 unless otherwise noted.

	Oct. 6, 1921 £	s.	d	Nov. 7, 1921 £	s.	d.
Anglo-American	4	0	0	4	16	3
Anglo-Egyptian B	1	2	6	1	2	6
Anglo-Persian 1st Pref.	1	1	3	1	1	9
Anglo-United, Wyoming		3	9			6
Apex Trinidad	1	13	9	1	12	6
British Borneo (10s.)		8	9		6	6
British Burmah (8s.)		17	6	1	0	0
Burmah Oil	4	17	6	5	15	0
Caltex ($1)		3	6		3	0
Dacia Romano		17	6		13	9
Kern River, Cal. (10s.)		19	3	1	1	3
Lobitos, Peru	4	0	0	3	15	0
Mexican Eagle, Ord. ($5)	3	10	0	3	7	6
,, ,, Pref. ($5)	3	7	6	3	2	6
North Caucasian (10s.)		13	9		11	3
Phœnix, Roumania		8	3		7	3
Roumanian Consolidated		8	6		6	9
Royal Dutch (100 gulden)	35	5	0	36	10	0
Scottish American		2	9		2	0
Shell Transport, Ord.	4	5	0	4	12	6
,, ,, Pref. (£10)	8	2	6	8	2	6
Trinidad Central	2	10	0	2	12	6
Trinidad Leaseholds	1	15	0	1	12	6
United British of Trinidad		13	9		12	6
Ural Caspian		12	6		8	0
Uroz Oilfields (10s.)		6	0		6	0

DIVIDENDS DECLARED BY MINING COMPANIES.

Date	Company	Par Value of Shares	Amount of Dividend
Oct. 19	Wolhuter Gold	£1	9d. less tax.
Oct. 19	Ginsberg Gold	£1	1s. 10d.*
Oct. 19	Goldfields Rhodesian	10s.	6d. less tax.
Oct. 19	Burmah Oil	£1	2s. less tax.
Oct. 20	Premier Diamond	Pref. 5s.	125 % less tax
Oct. 21	Amalgamated Zinc	£1	1s.
Oct. 22	Waihi Gold	10s.	1s. tax paid.
Oct. 22	Deebook Dredging	£1	6d.†
Oct. 24	Scottish Australian	£1	2½% less tax.
Oct. 27	El Oro	£1	1s. tax paid.
Oct. 28	Gold Coast Amalgamated	£1	2½% less tax.
Oct. 28	St. John del Rey	Ord. £1 Pref. £1	9d. less tax. 1s. tax paid.
Nov. 1	Borax Consolidated	Def. Ord. £1	1s. less tax.
Nov. 4	Lonely Reef	£1	15% less tax.
Nov. 7	Gaika Gold	£1	7½% less tax.
Nov. 7	Aramayo Mines	25 fr.	5 [illegible]

* Second and final distribution on liquidation.
† Refund of capital.

PRICES OF CHEMICALS. November 7.

These quotations are not absolute; they vary according to quantities required and contracts running.

		£	s.	d.
Acetic Acid, 40%	per cwt.	1	2	6
,, 80%	,,	2	5	0
,, Glacial	per ton	60	0	0
Alum	,,	16	0	0
Alumina, Sulphate	,,	14	10	0
Ammonia, Anhydrous	per lb.		2	2
,, 0·880 solution	per ton	28	0	0
,, Carbonate	per lb.			4
,, Chloride, grey	per ton	37	0	0
,, ,, pure	per cwt.	3	5	0
,, Nitrate	per ton	45	0	0
,, Phosphate	,,	85	0	0
,, Sulphate	,,	13	10	0
Antimony, Tartar Emetic	per lb.		1	6
,, Sulphide, Golden	,,		1	3
Arsenic, White	per ton	38	0	0
Barium Carbonate	,,	10	0	0
,, Chlorate	per lb.			11
,, Chloride	per ton	16	0	0
,, Sulphate	,,	8	0	0
Benzol, 90%	per gal.		3	0
Bisulphate of Carbon	per ton	56	0	0
Bleaching Powder, 35% Cl.	,,	16	0	0
,, Liquor, 7%	,,	6	0	0
Borax	,,	31	0	0
Boric Acid Crystals	,,	65	0	0
Calcium Chloride	,,	9	0	0
Carbolic Acid, crude 60%	per gal.		1	7
,, ,, crystallized, 40°	per lb.			6½
China Clay (at Runcorn)	per ton	4	10	0
Citric Acid	per lb.		2	5
Copper, Sulphate	per ton	30	0	0
Cyanide of Sodium, 100%	per lb.			11½
Hydrofluoric Acid	,,			7½
Iodine	per oz.		1	0
Iron, Nitrate	per ton	8	0	0
,, Sulphate	,,	3	0	0
Lead, Acetate, white	,,	45	0	0
,, Nitrate	,,	47	0	0
,, Oxide, Litharge	,,	38	0	0
,, White	,,	44	0	0
Lime, Acetate, brown	,,	8	0	0
,, ,, grey 80%	,,	11	0	0
Magnesite, Calcined	,,	21	0	0
Magnesium, Chloride	,,	12	0	0
,, Sulphate	,,	8	0	0
Methylated Spirit 64° Industrial	per gal.		5	0
Nitric Acid, 80° Tw.	per ton	30	0	0
Oxalic Acid	per lb.			9
Phosphoric Acid	per ton	40	0	0
Potassium Bichromate	per lb.			8
,, Carbonate	per ton	25	0	0
,, Chlorate	per lb.			6
,, Chloride 80%	per ton	12	0	0
,, Hydrate (Caustic) 90%	,,	33	0	0
,, Nitrate	,,	49	0	0
,, Permanganate	per lb.		1	3
,, Prussiate, Yellow	,,		1	3
,, ,, Red	,,		2	3
,, Sulphate, 90%	per ton	16	0	0
Sodium Metal	per lb.		1	4
,, Acetate	per ton	30	0	0
,, Arsenate 45%	,,	31	0	0
,, Bicarbonate	,,	12	0	0
,, Bichromate	per lb.			7
,, Carbonate (Soda Ash)	per ton	15	0	0
,, ,, (Crystals)	,,	7	0	0
,, Chlorate	per lb.			4
,, Hydrate, 76%	per ton	26	15	0
,, Hyposulphite	,,	16	0	0
,, Nitrate, 96%	,,	15	0	0
,, Phosphate	,,	22	0	0
,, Prussiate	per lb.			7
,, Silicate	per ton	11	15	0
,, Sulphate (Salt-cake)	,,	5	10	0
,, ,, (Glauber's Salts)	,,	5	0	0
,, Sulphide	,,	22	0	0
,, Sulphite	,,	12	10	0
Sulphur, Roll	,,	13	0	0
,, Flowers	,,	13	0	0
Sulphuric Acid, Fuming, 65	,,	24	0	0
,, ,, free from Arsenic, 144°	,,	6	5	0
Superphosphate of Lime, 30%	,,	7	10	0
Tartaric Acid	per lb.		1	5
Turpentine	per cwt.	3	9	0
Tin Crystals	per lb.		1	5
Titanous Chloride	,,		1	0
Zinc Chloride	per ton	22	10	0
Zinc Oxide	,,	41	0	0
Zinc Sulphate	,,	17	0	0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS:	Nov. 5, 1920	Nov. 7, 1921
RAND:	£ s. d.	£ s. d.
Brakpan	3 0 0	2 10 0
Central Mining (£8)	8 2 6	6 0 0
City & Suburban (£4)	7 0	2 6
City Deep	2 15 0	2 5 0
Consolidated Gold Fields	1 5 0	15 0
Consolidated Langlaagte	16 3	12 6
Consolidated Main Reef	14 6	9 6
Consolidated Mines Selection (10s.)	1 1 6	14 0
Crown Mines (10s.)	2 12 6	1 15 0
Daggafontein	12 6	2 6
Durban Roodepoort Deep	5 0	5 0
East Rand Proprietary	9 6	4 6
Ferreira Deep	12 0	8 6
Geduld	2 7 6	2 16 3
Geldenhuis Deep	8 0	5 0
Government Gold Mining Areas	4 5 0	3 18 9
Johannesburg Consolidated	1 6 6	1 1 3
Kleinfontein	6 6	5 3
Knight Central	4 6	4 6
Knights Deep	6 9	—
Langlaagte Estate	15 0	11 6
Meyer & Charlton	4 12 6	4 0 0
Modderfontein, New (10s.)	3 15 0	3 13 9
Modderfontein B (5s.)	1 15 0	1 6 3
Modderfontein Deep (5s.)	2 5 0	2 3 9
Modderfontein East	1 3 9	9 0
New State Areas	1 11 3	1 2 6
Nourse	10 0	9 0
Rand Mines (5s.)	2 18 9	2 1 3
Rand Selection Corporation	3 7 6	2 10 0
Randfontein Central	14 0	10 0
Robinson (£5)	7 0	9 0
Robinson Deep A (1s.)	12 6	8 9
Rose Deep	17 0	13 0
Simmer & Jack	3 9	2 6
Springs	2 2 6	1 18 9
Sub-Nigel	15 0	10 0
Union Corporation (12s. 6d.)	19 0	14 6
Van Ryn	15 0	12 0
Van Ryn Deep	3 15 0	3 8 9
Village Deep	9 3	8 0
West Springs	17 6	11 3
Witwatersrand (Knight's)	15 0	12 6
Witwatersrand Deep	8 0	8 0
Wolhuter	5 0	4 3
OTHER TRANSVAAL GOLD MINES:		
Glynn's Lydenburg	13 9	8 9
Sheba (5s.)	1 9	1 3
Transvaal Gold Mining Estates	10 0	8 0
DIAMONDS IN SOUTH AFRICA:		
De Beers Deferred (£2 10s.)	16 10 0	10 17 6
Jagersfontein	3 15 0	2 5 0
Premier Deferred (2s. 6d.)	9 0 0	5 0 0
RHODESIA:		
Cam & Motor	10 0	10 0
Chartered British South Africa	15 0	10 9
Falcon	13 0	4 9
Gaika	13 0	10 3
Globe & Phœnix (5s.)	17 0	12 6
Lonely Reef	2 17 6	2 3 9
Rezende	2 15 0	3 5 0
Shamva	1 12 6	1 10 0
Willoughby's (10s.)	5 6	3 6
WEST AFRICA:		
Abbontiakoon (10s.)	3 6	2 3
Abosso	10 0	6 6
Ashanti (4s.)	16 6	13 9
Prestea Block A	2 3	1 9
Taquah	13 9	8 6
WEST AUSTRALIA:		
Associated Gold Mines	3 0	2 0
Associated Northern Blocks	3 0	1 9
Bullfinch	3 3	1 0
Golden Horse-Shoe (£5)	15 0	11 3
Great Boulder Proprietary (2s.)	6 9	5 9
Great Fingall (10s.)	1 6	1 0
Hampton Properties	7 6	4 3
Ivanhoe (£5)	1 2 6	18 9
Kalgurli	13 9	17 0
Lake View Investment (10s.)	14 3	7 6
Sons of Gwalia	6 0	3 6
South Kalgurli (10s.)	5 6	8 0

GOLD, SILVER, *cont.*	Nov. 5, 1920	Nov. 6, 1921
OTHERS IN AUSTRALASIA:	£ s. d.	£ s. d.
Blackwater, New Zealand	8 9	2 6
Consolidated G.F. of New Zealand	3 9	2 6
Mount Boppy, N.S.W. (10s.)	6 0	3
Progress, New Zealand	1 9	1 3
Waihi, New Zealand	1 10 0	1 1 3
Waihi Grand Junction, New Z'lnd.	8 9	7 6
AMERICA:		
Buena Tierra, Mexico	11 3	1 9
Camp Bird, Colorado	12 9	3 6
El Oro, Mexico	15 6	9 0
Esperanza, Mexico	1 10 0	13 6
Frontino & Bolivia, Colombia	10 0	6 3
Le Roi No. 2 (£5), British Columbia	5 0	2 6
Mexico Mines of El Oro, Mexico	7 0 0	3 15 0
Nechi (Pref. 10s.), Colombia	8 9	4 0
Oroville Dredging, Colombia	1 7 6	1 0 0
Plymouth Consolidated, California	18 9	8 0
St. John del Rey, Brazil	16 3	15 0
Santa Gertrudis, Mexico	1 0 6	6 0
Tomboy, Colorado	10 0	5 0
RUSSIA:		
Lena Goldfields	15 0	7 6
Orsk Priority	10 0	5 0
INDIA:		
Balaghat (10s.)	8 0	7 0
Champion Reef (2s. 6d.)	2 3	3
Mysore (10s.)	13 9	10 6
North Anantapur	4 0	2 6
Nundydroog (10s.)	5 3	5 6
Ooregum (10s.)	13 3	11 6
COPPER:		
Arizona Copper (5s.), Arizona	2 1 3	17 6
Cape Copper (£2), Cape and India	1 0 0	10 0
Esperanza, Spain	5 0	5 0
Hampden Cloncurry, Queensland	12 6	5 0
Mason & Barry, Portugal	1 10 0	2 15 0
Messina (5s.), Transvaal	5 6	3 0
Mount Elliott (£5), Queensland	1 5 0	10 0
Mount Lyell, Tasmania	1 0 0	12 6
Mount Morgan, Queensland	17 6	11 3
Namaqua (£2), Cape Province	1 7 6	17 6
Rio Tinto (£5), Spain	29 0 0	27 0 0
Russo-Asiatic Consd., Russia	13 3	6 3
Sissert, Russia	11 3	5 0
Spassky, Russia	17 6	7 6
Tanganyika, Congo and Rhodesia	1 12 6	18 9
LEAD-ZINC:		
BROKEN HILL:		
Amalgamated Zinc	1 2 6	16 3
British Broken Hill	1 10 0	18 9
Broken Hill Proprietary	2 10 0	1 10 0
Broken Hill Block 10 (£10)	1 1 3	10 0
Broken Hill North	2 5 0	1 10 0
Broken Hill South	2 2 6	1 6 3
Sulphide Corporation (15s.)	15 0	10 0
Zinc Corporation (10s.)	13 9	9 0
ASIA:		
Burma Corporation (10 rupees)	12 6	6 3
Russian Mining	10 0	5 0
RHODESIA:		
Rhodesia Broken Hill (5s.)	10 9	5 0
TIN:		
Aramayo Mines, Bolivia	3 7 6	1 15 0
Bisichi (10s.), Nigeria	10 0	4 0
Briseis, Tasmania	4 0	2 6
Dolcoath, Cornwall	2 6	9
East Pool (5s.), Cornwall	10 3	3 0
Ex-Lands Nigeria (2s.), Nigeria	2 6	1 3
Geevor (10s.), Cornwall	10 0	2 9
Gopeng, Malay	1 15 0	1 12 6
Ipoh Dredging, Malay	15 0	10 0
Kamunting, Malay	2 10 0	1 0 0
Kinta, Malay	2 0 0	1 12 6
Malayan Tin Dredging, Malay	1 13 9	17 6
Mongu (10s.), Nigeria	18 9	8 9
Naraguta, Nigeria	11 3	12 6
N. N. Bauchi, Nigeria (10s.)	4 3	1 6
Pohang Consolidated (5s.), Malay	10 3	5 0
Rayfield, Nigeria	8 0	1 6
Renong Dredging, Siam	1 15 0	17 6
Ropp (4s.), Nigeria	8 9	4 6
Siamese Tin, Siam	3 2 6	1 15 0
South Crofty (5s.), Cornwall	11 9	3 6
Tehidy Minerals, Cornwall	15 0	5 0
Tekka, Malay	1 2 6	15 0
Tekka-Taiping, Malay	1 2 6	1 1 3
Tronoh, Malay	1 7 6	1 1 3

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also notices of new books and pamphlets, lists of patents on mining and metallurgical subjects, and abstracts of the yearly reports of mining companies.

RESOURCES OF THE MEXICAN OILFIELDS

A paper on this subject, by L. G. Huntley and Stirling Huntley, appears in the September issue of *Mining and Metallurgy*, the monthly organ of the American Institute of Mining and Metallurgical Engineers. It has been written as a counterblast to recent articles which predicted an early exhaustion of many of the areas in the so-called southern fields of the Tampico-Tuxpam district, and which were interpreted in many quarters, rightly or wrongly, to indicate an approaching collapse of the Mexican oil industry. The object of the present paper is to show that the life of the Mexican oil industry will be a long one, and that Mexican oil will continue to be a large factor in the market for an indefinite time after the areas forming the subject of the previous articles have been drained.

The author first describes the various producing areas of the southern fields. The first of the large wells was drilled in 1908 at Dos Bocas. This ran wild for two months and then turned to hot salt water, which it has continued to produce ever since. Several nearby smaller wells were flooded with salt water at the same time, and the pool ceased to produce. There is thus no history of production upon which to base comparisons with other fields. This is the farthest north of the structures that lie along the crest of the main fold which intersects the coast at this point.

The initial well of any importance drilled on the Tepetate-Chinampa structure was Juan Casiano No. 7, drilled in 1910. This well produced from the pool without competition until 1917, when several other pipe-lines were completed, and the Huasteca Petroleum Co. shipped approximately 85,000,000 barrels of oil from the pool, out of a total of approximately 126,000,000 produced. The pool was finally flooded in 1920. The salt-water table moved up the flanks of the structure with remarkable regularity as the oil was drawn off. Starting from the 2,175 ft. contour below sea-level, it moved gradually up to the crest, where the pay formation lay at an elevation of approximately 1,800 ft. below the same datum. The estimated area originally underlain by oil was 625 hectares, with a vertical height to the crest of the structure of 350 ft. at the highest point.

The Amatlan-Naranjos-Zacamixtle is the next independent pool south of the Tepetate-Chinampa. It is cut off from the field to the north by a sharp saddle or fault, and is separated from the Cerro Azul pool to the south by a low saddle, which is also probably accompanied by faulting. While there are several domes along this crest which may be separated by faulting, it is considered a single producing unit in this paper. Up to July 1, 1921, this district had produced approximately 120,000,000 barrels of oil. The salt-water table had risen on the northern end of the pool from the $-2,150$ ft. contour to the $-1,660$ ft. contour, while on the southern end in lower Amatlan, where the crest reaches a height represented by $-1,550$ ft. contour, the salt water had barely passed the 1,800 ft. contour, as shown in Fig. 2. On the southern end, this rapid depletion was largely due to low porosity. In July, there was an area of about 750 hectares still producing in both sections, with a vertical oil height averaging 110 ft. It is estimated, therefore, that on the above date there were approximately 50,000,000 barrels of oil remaining in the pool. At that time practically all shipments had been suspended on account of the Mexican Government's high export taxes. At the rate at which it was being drained in January, 1921, 400,000 barrels per day, it would last approximately 125 days; at the rate at which shipments were made in May, 1921, the field will not be drained until the middle of 1922. It is to be expected that all companies having producing wells within the limits of this pool will take most of their oil from these wells while the pool lasts, reserving for the future their wells in less competitive fields. The companies that control wells in Toteco and Cerro Azul are apparently following this obvious policy. As regards the Cerro-Azul-Toteco pool, the crest of the structure reaches a considerably higher vertical elevation above the salt-water table than those to the north, which have just been

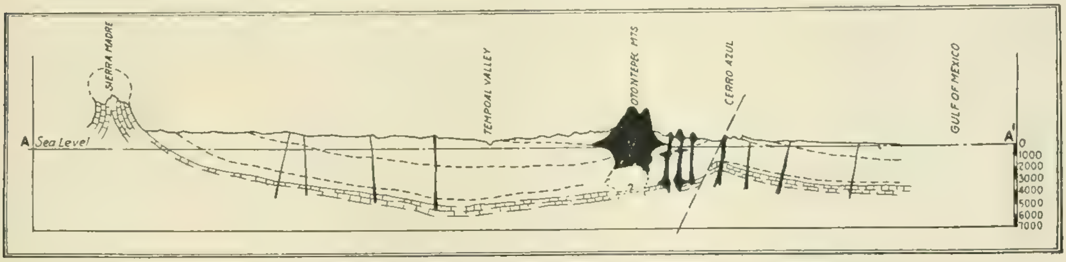


FIG 1.—DIAGRAMMATIC CROSS-SECTION OF TAMPICO EMBAYMENT

Showing main structural features and intrusives, in their relation to present and future oil development.

discussed, the highest contour apparently being −1,350 ft. The estimated area is approximately 1,350 hectares, with a vertical oil column of 450 ft. This greater vertical height of the structure represents a correspondingly greater cubical contents per hectare. By comparison with the Tepetate-Chinampa field, it is therefore estimated to contain a reserve of 150,000,000 barrels, making allowance for large amounts of gas in the reservoir in Toteco. About 54,000,000 barrels have been produced, the greater part of which has come from the Huasteca Petroleum Co.'s No. 4 well in Cerro Azul, which was drilled in 1914. This pool will be only partly competitive, as there are only three companies represented by leases and wells, although other claimants exist and may possibly obtain representation through title litigation.

The Potrero del Llano-Alazan pool, after producing approximately 117,000,000 barrels of oil, finally went to salt water in 1918. Since that time, however, by pinching in old wells and drilling strategic locations, a considerable daily production has been worked up, which was still maintained in July, 1921. The highest producing contour in this pool was about 1,750 ft. below sea-level on the Alazan end.

In the Tierra-Blanca-Chapapote pool, the first well was completed in May, 1921. The Tamasopa lime lies at approximately 2,000 ft. below sea-level in this well. In case the general salt-water level is the same on this fold as in the pools to the north (−2,250), the amount of oil to be obtained is relatively small. However, this remains to be determined. The territory is controlled by the Huasteca Petroleum Co., and it will therefore be a non-competitive pool.

The producing formation in the Alamo pool is a limestone some distance above the Tamasopa. Several pays are encountered, and at least two distinct grades of oil. Salt water has seriously invaded the small producing area, and the wells were stripping approximately 7,000 barrels per day before the shutdown. The pool has produced about 35,000,000 barrels of oil, but probably without affecting the nearby Tierra Blanca reservoir. The Alamo pool is controlled by the Penn-Mex Fuel Co., and therefore is non-competitive.

One well on the Molino pool has been drilled into a pay reservoir in the Tamasopa, at a depth of 2,710 ft.; this is the lowest producing big well in the Tampico Embayment. It is rated as a 20,000 barrel well, or better, but produces a heavy viscous oil of about 11° Bé gravity, which it has been impossible to pump to the coast. Conditions are more complex in the Tuxpam River district than in the region to the north. A good well has just been drilled in the Zapotal tract, south of the river, which produces a light oil in what is apparently the San Felipe series above the Tamasopa. It was, however, drilled deeper into the salt water.

The Panuco River pools lie along the crest of a broadly plunging arch, and produce both from the San Felipe and the Tamasopa formations. While locally there seems to be a general salt-water table below which no oil will be found, the porosity of the lime seems to be the main factor in determining its productivity in any particular area. Neither the Panuco nor the Topila districts has been finally delineated by dry holes, and there is good reason to believe that not only will they be extended, but that new areas will be brought in along the broad crest.

The value of any comparison of leases located on the crest of the folds in this region depends on the amount of oil the owners of such leases can ship and sell by means of their pipe-lines and organization during the time the total amount of oil is being depleted by all companies producing from the same pool. Also, certain wells at the extreme crests are found to continue producing for long periods when pinched in after the field as a whole is flooded. Companies that control such wells have a valuable asset as they may in the end give greater returns than the original wells.

After the Chinampa pool was drained, several wells at the crest were able to strip substantial amounts of oil by pinching in the wells, and this is also being done at Potrero and Alamo. It is expected that the Amatlan field will also offer the same possibilities. Meanwhile, the Panuco River fields to the north have not been delimited by dry holes, and continue to produce substantial amounts of oil, with the probability of increase in the future both in number and area. This may be shown as follows:—

Daily Production by Fields early in 1921 before Market Decline.

	Barrels Per Day.
Panuco River Fields	145,000
Amatlan-Naranjos-Zacamixtle	400,000
Cerro Azul-Toteco	30,000
Alamo	10,000
	585,000
Less Amatlan in 125 days will lower production to	185,000

But this disregards oil reserves from various sources, which may therefore be added and summarized as follows:—

Estimated Possible Daily Production by Fields after Amatlan Goes to Salt.

	Barrels.
Panuco River Fields	145,000
Tepetate-Chinampa (stripping)	10,000
Naranjos-Amatlan-Zacamixtle (stripping)	20,000
Cerro Azul (3 companies) (probably greater on account of sales to other companies)	140,000
Tierra Amarilla (stripping)	10,000
Potrero Alazan (stripping)	10,000
Alamo (stripping)	7,000
Tierra Blanca (non-competitive) (depending on company policy)	60,000
Total	382,000

Estimating the life of Cerro Azul and Tierra Blanca, with an estimated reserve of 200,000,000 barrels, at 1,000 days, on the assumption that they produce at the combined rate of 200,000 barrels per day after the Amatlan pool is drained, at the time of their being finally flooded, they in their turn should strip 10,000 barrels or more per day each from wells on the crests. This reserve will be partly sold to other companies and therefore will probably be pulled on much faster than this. While it is impossible to say how long this stripping can go on, there is good evidence that such wells will be long lived, as they are probably fed by oil working up the flanks of the structure over the entire former producing area. Much of this oil must have been cut off by the sudden flooding of the pools, and will now be largely available to such

FIG. 2.—STRUCTURAL CONTOURS OF SOUTHERN OILFIELDS.

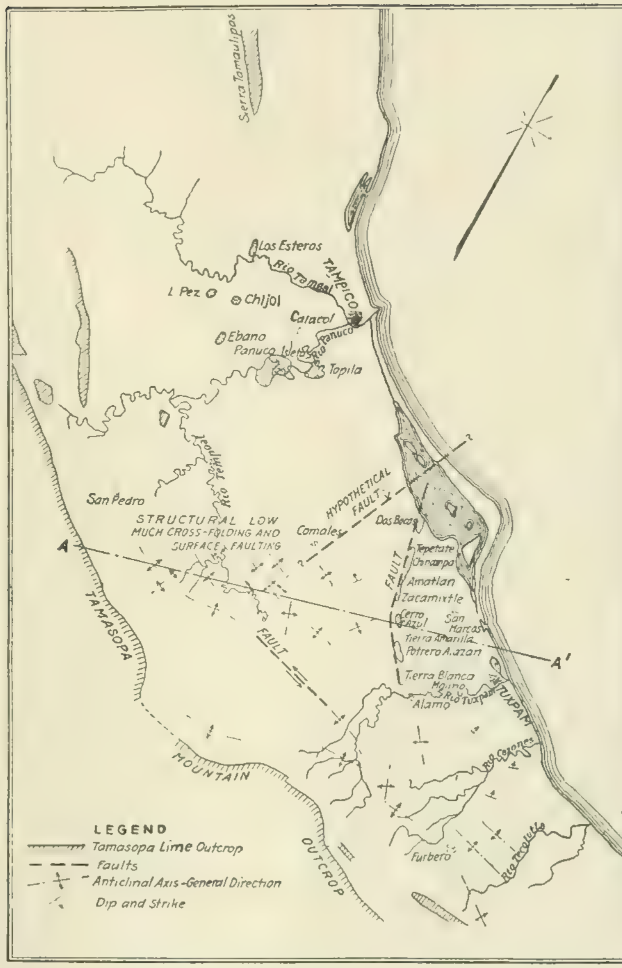


FIG. 3.—TAMPICO EMBAYMENT, SHOWING MAIN STRUCTURAL FEATURES WITH RELATION TO POOLS.

strategic wells as those mentioned. This will make it possible to estimate that, after all the southern pools have been flooded, there will still be a production in the Mexican fields of 250,000 barrels per day at the end of 1,000 days from July 1, 1921, on the assumption that the new drilling in the Panuco River field increases production. This alone is sufficient to be a considerable factor in the oil market, particularly the fuel-oil market. Meanwhile, it can be assumed that prospecting will have probably extended the producing areas in the Panuco River district, and those to the south and west of the Alamo. In the latter region there are good indications that there will be found pools of relatively light oil in sand and limestone formations above the Tamasopa as well as in the latter formation itself. In the case of the probable pools yielding from reservoirs above the Tamasopa, these will undoubtedly have smaller wells producing over a longer period of time in comparison with the large Tamasopa wells to the north. It is even possible, if later and higher prices warrant it, that this region will see pumps installed for the first time in Mexcio.

The present reserves in producing pools may be shown as follows :—

	Barrels.
Amatlan-Zacamixtle . . .	50,000,000
Cerro Azul-Toteco	150,000,000
Tierra Blanca	50,000,000
Panuco River pools . . .	?
(Have not been limited and seem capable of considerable extension)	
Total	250,000,000 plus

These amounts disregard later recoveries from the same areas through stripping wells, as the factor used in the calculations was derived from the data in the Tepetate-Chinampa area, which exclude later recoveries.

The authors proceed to discuss the geological factors involved. The oil from the fields in the Tampico Embayment has practically all been produced from porous limestone near the top of the Tamasopa limestone, or from that limestone itself. This limestone is not naturally porous, but has been channelled by underground water,

apparently associated with the igneous intrusions of late Tertiary age which are common in the field. Such cavities and channels are filled with oil on the crests of some of the main folds in the region, and, as would be expected, are filled with water down the dip on the flanks of the folds and in the basins. The large wells, however, are entirely dependent on the porosity of the limestone, and, as this porosity is apparently associated with the basaltic rocks found in certain parts of the region, it would seem to follow that where such intrusions were not present, or were infrequent, the limestone would be non-porous and wells non-productive or less productive. These conditions seem to prevail in the Tempoal Valley, and also north of the Tamesi River toward the Rio Grande, where intrusives are not only relatively scarce but in most cases are older in age than those to the south. Thus, while a few seepages exist north of the Tamesi Valley, and also in the Temporal Valley, they are as a rule small and "dead," or merely veins of asphalt or grahamite, as though leakage had long ago dissipated any possible underground accumulations of oil. The relative lightness of a few of these seepages in comparison with those found along the crests may be accounted for by considering them as filtered through a considerable vertical column of shale.

The migration of all fluids in the sedimentary formations in the Tampico Embayment must have been generally westward, that is to say, from the deep region of high rock pressures on the Gulf side in the direction of the mountain outcrop to the west. Any interruption to this migration must have been either the tops of folds, where the formations were sufficiently porous to catch and retain the oil above the general salt-water body, or fracture or fault zones which allowed it to escape to the surface, or both. In the Tampico Embayment there exists a line of folding flanking the coast, where both conditions exist. In fact, the groups of numerous live seepages at the surface were the first evidence of the fold itself noticed by the early exploiters of the field. Only remnants that could spill across the low places in the arch could get by this first line of folding. Immediately west of the crest of this first arch the number and size of these igneous intrusions increase greatly, and as each intrusion of basalt cutting through the upper formations is an outlet for the leakage of any oil underground, the territory to the westward suffers from the following disadvantages :—

(*a*) Less oil from migration ;

(*b*) More dissipation through having to pass a zone of intrusives in migrating westward ;

(*c*) General synclinal conditions favourable for water accumulation rather than oil, especially as the outcrop of the sandy San Felipe is open to infiltrating waters on the west at an elevation that would give it a head ;

(*d*) Proximity to mountain folding, with its accompanying heat and pressure, which may have destroyed some of the oil reservoirs.

The Tempoal Valley suffers from all of these disadvantages, but good structures on the flanks of such a basin may be expected to produce oil in relatively small amounts, even with a comparatively low porosity of the Tamasopa. The drilling carried on by the Pearson interests at San Pedro showed what may be expected. Such areas will be valuable as the older, more prolific fields become exhausted, particularly since this is a very high-grade oil.

The considerations that were disadvantages to the Tempoal Valley make the crest of the Panuco arch appear very attractive for the future. In the Panuco field, and the surrounding district, the oil accumulations seem to be comparatively independent of local structure and to be governed by the local porosity of the limestone. If this holds true generally, there will be a great deal more oil produced from this region, as in the northern part of the Embayment area this broad arch constitutes the first barrier to the migration of oil from the east and the south-east. The oil found apparently increases in specific gravity from the Panuco River to the north. That found at Los Esteros will barely flow.

North of the Tamesi River the Tamasopa lime outcrops in the Sierra Tamaulipas, an uplift which occurred during late Cretaceous times. Thus, this has been a leakage zone for a wide area of sedimentaries for a much longer time than leakage has been going on in the southern fields through the recent basaltic intrusives. The same conditions hold true of the zone immediately flanking the mountain outcrop of the Tamasopa, which bounds the Tampico Embayment to the west and south. Prospecting in such areas, between the first barrier to the east and the Tamasopa outcrop to the west should wait for the distant future.

From available surface evidence, and drilling that has been done up to the present time, it seems probable that the Dos Bocas-Alamo fold is plunging steeply south of the Tuxpam River. This would necessarily leave a gap in the main line of folding across which westward migrating oil could pass, to be caught by structural folds lying at the head of the sub-embayment west of this gap. Since certain of these folds are well marked, and have seepages and basaltic intrusives near their crests, they certainly give promise of favourable results when tested. These various favourable conditions are less in degree than on the structures along the present producing fold to the north and the strategic position of these folds is not so good ; but they constitute the type of structures that will be tested in the future. The chances seem good for bringing in fair-sized wells of lighter oil than the present fields yield.

As previously stated, to the south of the Alamo the evidence seems to indicate that the main fold is plunging rapidly, and will not connect directly with any fold in that direction. However, in the region between the Tecolutla and Cazones Rivers, a relatively sharp fold is found, which brings the Tamasopa lime within drilling distance of the surface. This fold apparently constitutes the first barrier fold east of the coast in this region, and as it contains both seepages and recent intrusives along its crest should constitute a good reservoir for oil. To the west and south-west of the barrier fold the Tamasopa is exposed at the surface, as is also the San Felipe. This territory cannot be considered particularly favourable, even though numerous seepages are found close to the mountain front. The general strike of the folding changes abruptly in the vicinity of the Nautla River, bringing the Tamasopa close to the surface along a fold with a N.E.—S.W. axis, which, together with the eastward limestone front to the south in the vicinity of Misantla, limits the Tampico Embayment in this direction.

In general, it may be predicted that any folds that bring the main reservoir rocks within drilling depth

along a zone flanking the coast, and which do not at the same time have their reservoir exposed, should be the best prospects for the development of oil production. The Furbero field produced from a volcanic sand found in the Mendez shales, a considerable distance vertically above the Tamasopa, while the recent well drilled by the Penn-Mex Fuel Co. at Zapotal encountered several good pay sands before reaching the Tamasopa limestone. Such folds in the extreme southern end of the Tampico Embayment area have the following advantages :—

(*a*) Well-defined structures in the same general region that has already produced oil ;

(*b*) Presence of typical surface evidence in the way of live seepages and recent igneous intrusions, which in the northern districts are accompanied by porous Tamasopa limestone underground ;

(*c*) Relatively shallow drilling depth at crests ;

(*d*) Same relative strategic position as the present producing fold north of the Tuxpam River ;

(*e*) Possibilities of additional oil-bearing formations above the Tamasopa. Both the San Felipe and overlying shales contain frequent beds of sand in this region south of the Tuxpam River.

The authors conclude by saying that it seems probable that the present fields will continue to produce oil in large quantities during the time necessary to carry on prospecting for additional pools. Certain of the areas now being explored or already in the hands of strong companies offer excellent possibilities for the development of important production. However, the opening up of these new fields will require new roads, railways, and pipe-lines, which will, in general, be longer and more expensive than the existing system of transportation, and some of which will in all probability have to be operated as units separate from those already installed. The existing transport system must in large part be liquidated out of the present producing fields. Costs of producing and operating will be higher than in the past, wells, in general, will be smaller, fields will be more disconnected. It is probable, however, that the oil in most new pools will be of a higher grade. These conditions will probably force upon the operators the use of co-operative or common carrier pipe-lines, railroads, telegraph lines, etc. In other words producing conditions will be more nearly like those of the United States than has heretofore been the case. It will be seen that the authors are fairly optimistic as to the future of these oilfields.

THE OILFIELDS OF EGYPT

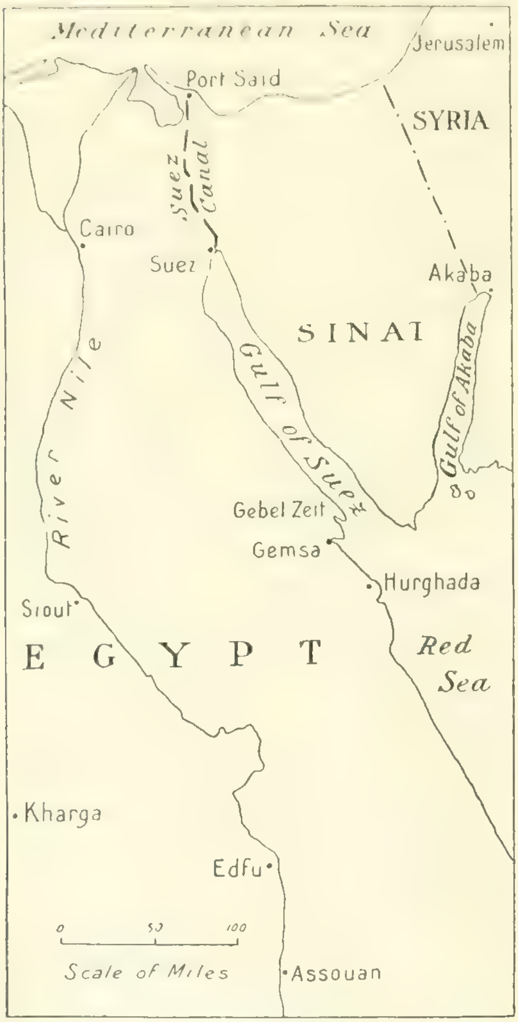
At the meeting of the Institution of Petroleum Technologists held on October 11, Dr. William Fraser Hume, director of the Geological Survey of Egypt, read a paper on the Egyptian Oilfields. We give an abstract herewith :—

The presence of petroleum in Egypt was known from very early times, its occurrence on the surface of pools at Gebel Zeit being recognized by the Romans, who named the locality *Mons Petroleus*. This now famous spot is situated at about 163 miles south-east of Suez on the western shore of the Gulf of Suez, and at the foot of a range some 1,400 ft. in height. When the Société Soufriere began the exploitation of sulphur on the peninsula of Gemsa in 1865, about 12 miles south of Gebel Zeit, tunnels were made into the gypsum containing sulphur close to the sea-shore. Considerable interest was aroused when petroleum was found to be floating on the sea-water which had collected in these excavations. The interest of the Egyptian Government in these oil occurrences began in 1884 when M. de Bäy called attention to the presence of petroleum in the old workings at Gemsa and at Gebel Zeit. It was arranged that he should undertake borings at these localities. The first boring reached a supply of oil at 106 ft., yielding 25 barrels a day, while a second well reached 137 ft., yielding 500 cubic metres a day of mixed oil and water. The Government, however, did not proceed further with the venture. In 1886 an expedition was organized under L. H. Mitchell, who was subsequently joined by Colonel Stewart, the British Consul-General at Odessa. Their results were embodied in two reports, which contained valuable data as to the distribution of petroliferous deposits in Egypt. In 1896 a new period of activity commenced with the formation of the Geological Survey under Captain (now Colonel) H. G. Lyons. In this year began the systematic geological examination of Egyptian territory, which has continued with increasing precision and detail up to the present day. This study led to the foundation of the present phosphate and magnanese industries but the visits to Gemsa and Zeit led to pessimistic conceptions of the oilfield possibilities. New impetus was given to prospecting when the Department of Mines was founded in 1906 under John Wells. Gemsa in particular was opened up, and in April, 1908, the first flowing well came in. A number of companies were formed in rapid succession after the initial success at Gemsa, but the failure of their efforts led to stagnation so far as companies were concerned, though the researches of the Government to obtain further light continued with unabated vigour. The opening up of the famous Hurghada oilfield further south again encouraged private enterprise, which, though checked by the war, has now been resumed with great energy.

With regard to the boring operations begun in 1908, No 1 well made good progress through dark limestone with subsidiary clays, and was drilled successfully to an oil rich in benzine on April 1, 1909. Other wells followed in fairly rapid succession, the first four being all oil producers, but of the twenty-one wells drilled only seven actually yielded petroleum, and of these only three were of first-class character. Though the oil itself was of valuable quality the supply fell off somewhat rapidly, and at the present time only one well occasionally has a small and very temporary production. The first geological results obtained were of a puzzling character. While the first well was entirely in limestone, those following showed alternations of gypsum and limestone in varying proportions. The oil-yielding zone was found to be a narrow belt bordering the sea ; to the westward of it the limestone diminished, the gypsum increasing in importance, while finally salt in great masses became the essential feature in a boring made to test the main anticline near Gemsa Bay. The petroleum was apparently present in porous calcareous members of a thick gypsum limestone series, the age of which has now been definitely

determined as not earlier than the Lower Miocene. Immediately an underlying sandstone was encountered (presumably the Nubian sandstone formation), the presence of oil was replaced by that of water.

The years 1908 to 1913, inclusive, were marked by an effort to determine the oil-producing possibilities of a number of small anticlines present on the main coast of Egypt, near Gemsa, and on the adjoining islands. Mr. John Wells commenced



MAP SHOWING POSITION OF EGYPTIAN OILFIELDS.

operations almost simultaneously at Ras Bahar (February 23, 1910), Gaysum Island (March and April, 1910), and Jubal Island (June, 1910), these being conducted on behalf of the African Prospecting Syndicate and Eastern Petroleum Company respectively. At the same time (June 27, 1910), the Egyptian Oil Trust began boring on Um el Haimet Island, situated eastward of Gemsa, and separated from it by a relatively shallow sea channel. The results, if instructive from the point of underground structure, were most disappointing as regards oil possibilities. At Ras Bahar the deeper No. 1 bore traversed nearly 3,000 ft. of alternating gypsum, shale, and salt; on Gaysum the same salt-containing series began at 450 ft. below surface, the salt (sometimes in continuous masses over 200 ft. in thickness) alternating with shales and gypsum to the depth attained, 2,668 ft. In the Jubal Island the results were different, where the earlier borings began in gypsum, then passed through dolomitic limestones which contained petroleum in small quantity. No large supplies had been met with before red granite was entered. Five other borings undertaken on this island showed increasing thicknesses of shale and gypsum away from the centre of the dome. The Um el Haimet borings equally indicated the presence of salt zones, their alternation with gypsum and clay, and in addition the presence of granitic sands of varying thickness distributed between 1,280 and 1,710 ft. below surface.

Drilling in 1911 and 1912 revealed the presence of the gypsum, clay, and salt series at Ramin Island, near the south end of Gebel Zeit, and also at the extreme northern end of that range, north-west of Ras Dib, near where the valley Wadi Dara enters the sea. As none of these salt-containing bores have shown any satisfactory indications of petroleum, it remains doubtful at present whether such anticlines as those above-mentioned would yield results if the deeper strata were penetrated. Another series of borings begun in 1910 were in the meanwhile presenting records of a different character, these being sunk at various localities at the southern end of the Gebel Zeit peninsula. The first was located near the surface seepage, and was carried to a depth of 610 ft., when it was abandoned on meeting the igneous rocks. Two others were begun on a small anticline north of Zeitia Harbour in April, 1911, and closed down in March, 1912. In these borings limestone played an important part, and some thin bands were saturated with petroleum, but these were not of sufficient thickness to be producers. A fourth was begun in June, 1912, and small thicknesses of salt were encountered. The work was abandoned at 1,322 ft., when granite was recorded as having been entered. So far the borings had thrown but little light on the deeper-seated structure, but one sunk on the western side of the Zeit range, early in 1913, went through a more normal succession, such as was indicated at the surface. Beneath a considerable thickness of gypsum and clay followed a fairly thick limestone which contained a certain amount of petroleum. Drilling was continued to 1,193 ft., when the Nubian sandstone was entered, a strong supply of water being then encountered. The effort was then discontinued. This boring, it should be stated, was well down the western limb of the anticline.

Up to this date the efforts to develop the minor anticlines had failed both on the Egyptian mainland and on the islands, the only oil obtained being along a line at Gemsa, which did not display striking anticlinal characters. In none of the localities tried were there any surface indications.

In 1909 it fell to the author's lot to push southward to the Hurghada anticline, and in March, 1911, his interest was greatly aroused by the discovery of an oil-smelling limestone in the western anticline of Hurghada. From this time onward, the Egyptian Government paid special attention to the Hurghada area. The Anglo-Egyptian Oilfields, Ltd., was also attracted to the region. The success of this enterprise is now a matter of history, a series

of gushers being obtained from late in 1913 to the present day.

Until 1912 the geology of the oilfield region remained wrapped in a considerable amount of obscurity. New data were, however, obtained in that year, which threw a flood of light on many points hitherto obscure. During the author's expedition of that year a young Arab chainman found a number of sea-urchins in a limestone underlying the great gypsum-clay series in Wadi Kabrit, at the northern end of the Zeit range, and further up the valley a rich fauna in the same formation was obtained containing such typical Miocene fossils as *Aturia aturi* and *Terebratula Miocenica.* These were identified as belonging to a period transitional between the lower and middle Miocene, and in this connexion it may be recalled that the late Professor Suess regarded *Aturia aturi* as the type fossil of the Schlier shallow-water formation which forms the lower section of the middle Miocene in Austria. This settled any controversy as to the age of the gypsum bordering the Red Sea.

When examining the oilfield area about 1905–6, Dr. Erb and John Wells found that a series of marls underlying the gypsum in Gebel Zeit, and in places over one hundred feet in thickness, were filled with the minute tests of the foraminifer *Globigerina.* This interesting formation was subsequently proved to extend throughout the Gebel Zeit range. The Petroleum Research studies in 1918 indicated the Miocene succession to be as follows :—

Upper gypsum beds.
Intergypseous clays and limestones.
Lower gypsum beds.
Globigerina marls.
Lower Miocene limestones, with flint conglomerates at the base.

The Gemsa oil was undoubtedly obtained from porous limestones belonging to the above series, and it is to this source that geologists look for any benzine-rich light oils that may yet be found in Egypt.

The most important advance in the knowledge of the distribution of oil in Egypt was indicated when the geologist of the Anglo-Egyptian Oilfields, Ltd., was permitted to disclose some of the results of his investigations at Hurghada to the author, in return for information supplied regarding the surface structure at Gebel Zeit. On comparing notes it was found that all representative members of the Zeit series were represented in the underground succession at Hurghada, including such characteristic members as the *globigerina* marls and the flint conglomerate. Beneath the conglomerate was a succession of fine sands and carbonaceous shales similar to beds well known in Upper Egypt as members of the upper Cretaceous formation. The lighter oils were found associated with calcareous strata in the Miocene gypsum-limestone series, the heavier oils being, on the other hand, present in the fine-grained Cretaceous strata.

This interesting conclusion brought the oil geology of Egypt proper into relation with that of the Sinai Peninsula. In 1888 Colonel Stewart learnt that petroleum was frequently found floating at low tide on the sea at Abu Durba, twenty-five miles north-westward of Tor, the quarantine port of Sinai. Oil seepages were also noted on the shore near Gebel Tanka, north of Abu Zenima, this leading to boring operations in August, 1910. The deepest of these reached a depth of 2,930 ft. Commencing in beds of Eocene age it traversed the whole of the fossiliferous Cretaceous strata, finally entering the Nubian sandstone. An oil-yielding layer was struck between three and four hundred feet from the surface, but as the supply was only three barrels a week the enterprise was eventaully abandoned. The Petroleum Research study of the Egyptian Government was extended to the Sinai Peninsula in 1917–18, detailed examinations being made of the Abu Durba and Tanka areas. It was evident that petroleum had been present in both the Eocene, Cretaceous, and Nubian sandstone formations. oil-rock being found at several horizons. The most consistent development is in the Cenomanian strata immediately above their junction with the Nubian sandstone. On the other hand, where the fossiliferous Cenomanian strata are not present, having passed into the sandstone type, the first limestone or marly strata above the sandstone show evidence of the former presence of oil, or it may be present in the underlying sandstone. Thus indications of the former presence of petroleum have been noted in almost every member of the Cretaceous and Eocene succession. Moon and Sadek have found repeated indications of its wide distribution in the Cenomanian strata of North Sinai ; at Abu Durba, where the lowest fossiliferous limestone is Turonian, the sandstone immediately below is highly bituminous, and has been proved still to contain thick liquid petroleum at only a few feet below the surface ; at Abu Zenima the oil-impregnated strata are at a higher Cretaceous horizon, the Santonian, while in the Tanka area Eocene beds have both yielded petroleum in borings and have also been highly impregnated with oil near the surface. The Cenomanian strata of Sinai are the lowest in the geological scale to contain indications of petroleum. The Jurassic strata in the northern hills of Sinai are in lithological structure most favourably developed to act as oil repositories, yet careful search has not yielded the slightest evidence of the former presence of petroleum in them. The same holds true for the Carboniferous strata in Western Sinai, and, so far as known, Wadi Araba also, on the Egyptian side.

IRON ORES IN SOUTH-WEST AFRICA

In the *South African Journal of Industries* for September, Dr. Percy A. Wagner gives an account of iron ore deposits in the Namib desert, from 10 to 16 miles to the south-east of Walfish Bay. He finds that the ores are highly siliceous, and not suitable under present conditions for use as a source of iron.

The Namib desert is for the most part flat and featureless, and, apart from its waterless character, easy to traverse. To reach it, however, it is necessary to cross the great belt of sand dunes extending along the coast from the neighbourhood of Luderitz Bay to the Swakop River. The belt is at its narrowest in the area under review, but none the less offers a most serious obstacle to transport, and the only practicable method of getting the iron ore to Walfish Bay would be by aerial tramway. The deposits are all of sedimentary origin, and, with one exception—a deposit of magnetite-garnet rock—consist of itabirite belonging to the

Fundamental Complex. The itabirite forms narrow [illegible] 50 ft. in [illegible], which in some instances run almost in a straight line for considerable distances, while in other instances the [illegible] of folding and faulting follow a sinuous course. The itabirite, being more resistant to atmospheric weathering than the other members of the Fundamental Complex, gives rise to low black ridges and kopjes which stand out prominently from the light-coloured surface of the Namib. Another consequence of the highly resistant nature of the ore is that the slopes of such kopjes, and in some instances even the flats surrounding them, are covered with black ironstone rubble, giving the inexperienced observer an exaggerated idea of the extent of the deposits. Five separate occurrences were examined. The itabirite everywhere presents much the same features, and in regard to several of the occurrences it is highly probable that they are repetitions by folding of the same bed. One of the most interesting points brought out by the writer's investigations is that there are fairly extensive ancient workings on at least two of the occurrences. These take the form of shallow pits and trenches, now for the most part filled with coarse, wind-blown sand. They are no doubt attributable to Hereros and Berg Damaras—skilled workers in iron—who inhabited the Walfish Bay territory until about the year 1840, when they were driven northward by the Hottentots of the so-called Red Nation under the redoubtable Jonker Afrikaner. The ore was probably smelted at Rooibank on the Kuiseb with charcoal made from camel thorn or other hardwood trees growing in the river-bed.

In its more typical development the itabirite is a regularly banded blackish rock composed essentially of iron oxide and quartz, for the most part segregated in well-defined layers, but sometimes intimately intermingled. The individual layers range in thickness from a fraction of a millimetre to 6 centimetres. The iron oxide is mainly specularite occurring in the form of thin plates and scales from 0·2 to 0·8 millimetre in diameter, arranged parallel with the banding or foliation. In addition to the normal specularite there is always present, in the form of small grains and crystals, a variety of greyish lustrous hematite, which may be martite pseudomorphous after magnetite. It forms impersistent layers up to 4 millimetres in thickness. Magnetite itself is only very sparingly present in these rocks. The siliceous or quartzitic bands, which vary in colour from pale-grey to dark-bluish grey, are composed essentially of a mosaic of interlocking grains of quartz from 0·2 to 1 millimetre in diameter. Many of the larger quartz grains are seen under the microscope to enclose tabular crystals of specularite arranged parallel to the schistosity, clear proof that the recrystallization of the quartz occurred during or subsequently to the foliation of the rock. Some varieties of the itabirite contain a small proportion of brownish-red garnet (almandine) in the form of irregular grains generally enclosing quartz and specularite. The garnet is sometimes imbedded in the iron oxides, but more usually occurs in association with quartz in lenticular eyes lying parallel with banding. Other accessory minerals present in small amounts are apatite and rutile.

On Von Broen's claims, situated about ten miles south-east of Walfish Bay, a bed of itabirite traceable over a distance of about 1,600 yards builds a conspicuous row of black kopjes running in a N.E.–S.W. direction along the edge of a broad expanse of gravel-covered desert known as the Plum; the kopjes themselves flanking a low, rugged, quartzite plateau. The itabirite bed appears to range in thickness from 6 ft. to fully 80 ft., the reason of this great variation not being apparent. It is intercalated with dark, fine-grained quartzite, containing a good deal of specularite in the form of minute grains and scales. The quartzite is seen at several points to be intersected by veins of coarse pink pegmatite with which the veins of pegmatitic quartz occurring in the itabirite are no doubt connected. In the first kopje the strike ranges from N.W.–S.E. to N.N.W.–S.S.E., the dip being toward the north-east. In the next, situated about 100 yards to the north-east, the strike is north-east to south-west, and the dip apparently vertical; beyond this the bed strikes toward the north, and then, again, follows a N.N.E.–S.S.W. course. To the north east of the fifth kopje the bed is cut off by a fault, and on the sixth it is seen to be disposed in the form of a closely compressed fold, the dip being practically vertical. In the seventh kopje the strike is N.E.–S.W., then approximately north and south; in the four most northerly kopjes the strike is more regular toward the north-north-east, the dip being almost vertical. The first and eighth kopjes are most prominent, and on these there are extensive ancient workings. The ore is very variable in character; it is made up of alternations of iron-rich and iron-poor layers, the former rarely exceeding a few inches in thickness. It is thus possible to obtain from the same outcrop all gradations from pure iron ore composed almost entirely of specularite to quartzite almost free from specularite. The average grade, such as would be obtained by mining on a large scale without sorting, is distinctly low. Thus an average sample of the ironstone building the first hill showed on analysis:—

	%
Fe . . .	37·7
SiO_2 . .	46·8
P . . .	0·15
S . . .	0·25

This material cannot be classed as iron ore. By selective mining and sorting a much better quality of ironstone could be obtained, but it is very doubtful whether in any circumstances a grade of over 53% could be maintained, as a picked sample of the best ore exposed on Hill No. 7 only showed 53·2% of iron and 19% of silica, and a sample of picked ore analysed some years ago in the State Laboratory at Hamburg, 53·1% of iron and 21% of silica.

A sample of itabirite from Von Broen's claims which was sent to Germany for analysis some years ago was found on analysis to contain 1·8 oz. of silver per ton and traces of gold. This led to the deposit being tested for precious metals by the engineers of the Deutsche Kolonial Gesellschaft für Süd-west Afrika. A bulk sample was taken and analysed with the following result: Iron 26·3%, gold *nil*, silver *nil*, platinum *nil*, so that in this sample none of the precious metals sought was present. The sample from Hill No. 1 taken by the writer was found, on the other hand, to contain 1·3 dwt. of silver and 3·5 dwt. of gold per short ton. It would appear, therefore, that small quantities of gold and silver are sporadically scattered through the itabirite, as is also the case with some of the itabirites of Brazil and with some of the banded ironstones occurring in the Union and

Southern Rhodesia. The amounts of the precious metals indicated by the analyses are insufficient, however, to warrant the expectation that either of them will be found anywhere to be present in profitable quantities.

On Murray's claims, situated two miles due south of Von Broen's, there is a long low ridge built up of a persistent vertical bed of banded itabirite about 600 yards in length striking N.E.–S.W., which for part of its length is paralleled on the south-east by a shorter bed of the same rock. It is probable that here are the two limbs of a very steep fold, pitching toward the south-south-west, but this could only be established by trenching. There are fairly considerable ancient workings now filled with coarse sand along the crest of the ridge. The width of the ironstone ranges from 20 yards downward. It is made up of alternations of specularite and quartzitic matter, the latter being in some instances of a cherty nature. Here, as on Von Broen's claims, it is possible to pick out specimens of very pure iron ore composed almost entirely of specularite, but the average grade is not very high. A sample taken by the writer of ore of more than average richness and probably fairly representative of the grade that might be maintained, if selective mining and sorting were practised, gave on analysis the following result :—

	%
Fe	57·7
SiO_2	17·6
P	0·05
S	0·35

A representative sample of the ore analysed by George T. Holloway & Co., Ltd., of London, showed :—

	%	
Fe_2O_3	65·32	Total iron 46·39%
FeO	0·90	
SiO_2	32·87	
Al_2O_3	0·69	
S	0·094	
Mn	0·048	
Ti	—	
Ca	—	
Mg	—	
Total	99·92	

A picked sample of the rich ore showed :—

	%
Fe	61·94
SiO_2	11·45
P	0·07

About 2½ miles to the south-east there is a similar but smaller hematite occurrence. The ore is again composed essentially of quartz and specularite, but also contains dark brownish-red garnet as an accessory constituent. It forms a vertical or steeply dipping bed some hundreds of yards in length and apparently averaging about 6 ft. in thickness. The strike is from north-east to south-west. A fairly representative sample of the ore was found on analysis to contain :—

	%
Fe	48·4
SiO_2	26·1
P	0·05
S	0·06

A mile to the south of this there is a long black outcrop formed by what may be a repetition by folding of the same bed. The ore here is much richer in garnet, this being the occurrence in which the itabirite encloses lenticular bands of a very coarsely crystalline aggregate of lustrous specularite, garnet, and bluish-grey quartz. A sample of the more typical itabirite gave on analysis :—

	%
Fe	41·2
SiO_2	30·8
P	0·06
S	0·09

The last of the itabirite occurrences to be examined is situated about 4½ miles north-west of Rooibank. It is a steeply dipping bed apparently ranging in thickness from 5 to 10 ft., the outcrop of which can be traced for about a mile. The itabirite is interbedded with coarsely crystalline white limestone containing a number of interesting contact minerals. The ore is very variable in character and its iron content probably ranges from 50% to 10% and less. A fairly representative sample showed :—

	%
Fe	38·2
SiO_2	44·5
P	0·1
S	0·3

A short distance to the south of this is a narrow belt of a coarsely crystalline magnetite ore forming a succession of low hog-backs, the total length of outcrop being about 400 yards. The ore is a coarse aggregate made up in variable proportions of magnetite in crystals and pieces up to 1 in. across, brownish-red garnet, and quartz, the magnetite predominating. It is in places distinctly banded, but, as a rule, the banding is barely perceptible. The grade is again very variable. A representative sample showed :—

	%
Fe	52·2
SiO_2	25·8
P	0·10
S	0·30

The magnetite rock is intercalated with crystalline limestone and lime silicate rocks.

Notwithstanding the unfavourable geographical situation of the deposits, it would have been practicable had any of them contained really large quantities of high-grade ore, that is, ore containing not less than 60% of iron and not more than, say, 4% of silica, to export this ore at a profit from Walfish Bay. Actually, however, while two of the deposits—namely, those on Von Broen's and Murray's claims — are of fairly considerable magnitude, none of them is, in the opinion of the writer, capable, even with selective mining and sorting, of yielding commercial quantities of ore averaging over 53 to 57% of iron and under 17 to 19% of silica. Ore of this grade, being in normal times worth only from 15s. to £1 per long ton, c.i.f., European and American ports, could not possibly be exported at a profit, as the cost of mining, sorting, and transport to Walfish Bay would be at least 10s. per ton. To send it by rail to the smelting works at Pretoria and Vereeniging would be equally impracticable, as immense supplies of this grade are available in the Transvaal. To smelt it on the spot is quite out of the question. The deposits are thus evidently not worthy of exploitation as a source of iron at present.

THE PECHEY COPPER-LEACHING PROCESS

In the July issue our West Australian correspondent gave the latest news about the Whim Well and Mons Cupri copper deposits in the north-western part of West Australia. Since then a report on this district by T. Blatchford, the Assistant State Mining Engineer, has been published. We extract herewith his remarks on the Pechey process, as used at these mines for extracting copper from the dump ores. As mentioned in July, the point of the process is the use of sulphurous acid in altering ferric sulphate to ferrous sulphate. The process has been used at the Mount Hope copper mine in New South Wales, and the information given by Mr. Blatchford combines the experience of Mr. Audley Smith, of Mount Hope, and of the engineers at Whim Well. But Mr. Blatchford is doubtful about the process, and recommends further official investigation.

At Whim Well the practice begins with 3 to 4 tons of sulphuric acid being diluted and poured over ore in leaching vats containing ore averaging 6% of copper in the form of carbonates and oxides. The object of the leaching vat is twofold. In the first place the ore used is the finer and richer portion of the dump, so the action of the solutions is more rapid and more copper is dissolved. Secondly, the oxygen of the ore acts as a powerful oxidizer to form ferric sulphate. The resulting solutions, on being drawn off, contain free sulphuric acid, copper sulphate (the amount of copper depending on the grade of the ore and length of time of contact), and varying proportions of ferrous and ferric sulphates. The proportion of ferric to ferrous sulphate depends on the amount of oxygen which had been obtained from the air during the time the solutions were percolating through the ore; also as will be pointed out later on, to the amount of oxygen derived from the copper oxides dissolved. It is a good practice to have all the ferrous converted to the ferric state. Assuming this is the case, or nearly so, the solutions are then fit to be passed over pyritic filters to reduce the ferric salts back to the ferrous state, and, at the same time, liberate some portion of the sulphuric acid to aid precipitation of the copper on the scrap iron, and also to prevent the precipitation of iron with the copper, which is the case in the presence of any appreciable amount of ferric sulphate. The pyritic filters mentioned are vats with false porous bottoms, on which is placed the pyritic ore; the flow of the solution is down a pipe and up through the pyritic ore, passing from one vat to another through the series.

In perfect practice all the ferric salts should be reduced to a ferrous state before entering the precipitation vats. If much ferric sulphate is present, there is always the danger of forming basic ferric sulphates, which, though soluble in sulphuric acid, are liable to be discharged from solution when the acidity is reduced below a certain point.

The following equation illustrates the ideal reaction in the pyritic filter :—

$$2FeS_2 + 11\ Fe_2(SO_4)_3 + 12\ H_2O = 24\ FeSO_4 + 12\ H_2SO_4 + S$$

In practice the following are typical analyses of what may be considered fairly normal working solutions when copper is present as chalcopyrite in the sulphide ore :—

	Copper grains per gal.	Ferrous Iron.	Ferric Iron.	Free H_2SO_4.
Entering filter .	20·98	13·32	15·66	6·00
Leaving filter .	39·64	25·10	1·74	20·00

The solutions from the pyritic filter are passed over scrap iron and leave with increased ferrous salts, little, if any, free sulphuric acid, and copper sulphate practically absent. The copper precipitated in the vats forms a precipitate containing about 70% metallic copper. From the precipitating vats the solutions are passed over the big dumps of broken ore in order to dissolve more copper and gain oxygen to convert the ferrous salts back to the ferric state. In the dump sulphuric acid is probably generated to a slight extent by the formation of basic sulphates by hydrolytic action. The solutions leaving the dump should therefore contain more copper sulphate, almost no free sulphuric acid, and a very much increased proportion of ferric sulphate. Before returning the solutions from the dump to the leaching vats the cycle is completed by first passing them through what is known as a converter vat. This vat is deep in proportion to its width, 12 ft. by 10 ft., and is provided with an air-lift and a filter bottom, on which is laid a layer of stones. The air-lift is external and connected to the bottom of the vat from the outside. SO_2 fumes, which are generated by burning sulphur in a closed vessel with air supplied under pressure from an air compressor, are passed down a central tube in the vat to underneath the filter bottom. They, therefore, naturally ascend through the liquid in the vat. The object of the filter bottom and stones is to break up the gas so that it will not concentrate in any particular portion of the solution in the vat, but be uniformly distributed throughout. The chemical action which takes place here is represented as follows :—

$$Fe_2(SO_4)_3 + SO_2 + 2\ H_2O = 2\ FeSO_4 + 2\ H_2SO_4$$

The leaching vats at Whim Well, already described, are three in number, and are calculated to hold 45 tons of ore when full. The dimensions are 20 ft. by 4 ft. Twenty vats 7 ft. by 6 ft. were installed in precipitation, but five of these are now used as pyritic filters, and fifteen only for precipitation. Dump leaching is carried on in a similar method to that in the Rio Tinto process. The top of the dump is divided into small paddocks 10 ft. by 4 ft. in area and the solution is poured into the paddocks in rotation. A constant flow of solution is not effective. What is wanted is an intermittent flooding and drying. A block of the ore, even weighing many pounds, when saturated with solution and allowed to dry soon becomes green on the outside. The copper has been attacked by the acid, and the soluble salts come to the surface by capillary action. Subsequent floodings dissolve and convey these salts away to the precipitation vats. The air-lifts are made of earthenware pipes.

In the dump-leaching a series of paddocks have been top-dressed with pyritic ore to increase the iron sulphates, and when working properly should be a further means for generating sulphuric acid. Owing to the corrosive nature of the solutions and the benefit derived from aëration, pipes are not used, and all liquors are circulated by means of hardwood launders, except the air-lifts, which at present are earthenware.

The process as described and used at Whim Well is based on actual practice at Mount Hope, in New South Wales, where 40,000 tons of waste dump containing 3·2% of copper has been actually treated, the percentage of copper in the dump being reduced to 1%. This work has extended over a period of six years' intermittent treatment. Though the process here has proved an undoubted commercial success, considerable advances in the treatment have since been made by the patentees. It has been found in practice that the original process, though giving the required reactions, was slow, and by adopting certain alterations in the mechanical handling of the material to be treated, the solutions could be made more active, and brought up to a more concentrated form.

The author then gives an account of the practice at Mount Hope. The essential point in the successful working of the Pechey process is the formation of ferric sulphate. To effect this the method of treatment as adopted at Mount Hope is based on the fact that if ferrous sulphate solutions be agitated with sulphur dioxide and air, in the presence of copper oxide, the following action takes place rapidly as follows :—

$$4\,FeSO_4+4\,SO_2+3\,O_2+2\,CuO=2\,Fe_2(SO_4)_3+2\,CuSO_4$$
and $Fe_2\,(SO_4)_3+SO_2+2\,CuO = 2\,CuSO_4+2\,FeSO_4$.

The speeding up of the reaction is due to the presence of the copper oxides in a fine state of division. From a chemical point of view the action is the same as in vat leaching. Water being always present in excess in the event of the copper oxide being insufficient to produce chemical equilibrium in accordance with the foregoing equations, the result would doubtless be as occurs in the converter. $Fe_2(SO_4)_3 + SO_2 + 2\ H_2 = 2\ FeSO_4 + 2\ H_2SO_4$. There is probably always free sulphuric acid in the solution when the process is in operation. The mechanical device to effect the speeding up is as follows : The ore is fine ground and treated in a series of Pachucas, the pulp being agitated with air and SO_2 gas. By adopting the slime treatment in the Pechey process the extraction of the copper is more rapid, the copper is accumulated to a higher percentage in the solutions, which can be more concentrated than in ordinary leaching, precipitation in the scrap iron is more perfect, and the copper cement is higher grade.

The chemical reactions in the process are not quite clear, and the literature on the subject is far from being complete. The treatment being a comparatively recent process, there appears to be much still open for discussion and investigation For instance, the formation of basic sulphates in the solutions when charged with ferric sulphates is in no instance referred to, and as this reaction will be dependent largely on percentages of free sulphuric acid and temperatures, it may have quite an important bearing on the costs and adjustments in the treatment. The class of sulphide ore used in the pyritic filters, control of solution going to the precipitating vats to obtain a high-grade cement, etc., need investigation. Mr. Blatchford has discussed the subject freely with the chemists in the Geological Survey and recommends that they be called in to investigate the points referred to above, as well as any others which may arise.

Gröndal Flotation Process in Germany.—A. Macco, in *Metall und Erz* for May 8 last, gives an account of Gröndal flotation plants in Germany. According to the author most of the experiments in flotation had lapsed into quietude before the war, a quietude from which they were awakened in the endeavour to meet war necessities. In 1918 the Boxbach Company operating near Breidenbach in the Biedenkopf district applied Gröndal machines to the concentration of poor copper ore. This equipment was followed with one of similar machines at Gottesgabe, near Roth, in the same neighbourhood, to recover fahlerz. Later, in January, 1920, the Gröndal flotation equipment erected at the Friedrich-August works, near Nordenheim, for war purposes was put into use by Beer, Sondheimer and Co., of Frankfort, for large-scale experiments upon the Rammelsberg lead-zinc ore. Finally, a fourth Gröndal equipment, begun during the war by the Antweil Co. at its Wilhelm mine in the Upper Ahr valley, and completed with the co-operation of the Stolberg Lead and Zinc Co., was brought into commercial operation.

Of these equipments the position now is that the Boxbach Company, working on a small deposit, has stopped ; Gottesgabe awaits the development of a deeper level ; the equipment at Friedrich-August is temporarily out of commission while certain defects are being made good ; and that at the Wilhelm mine awaits the completion of secondary plant. Though this is not a rosy picture, the author considers the experiences obtained are worth recording.

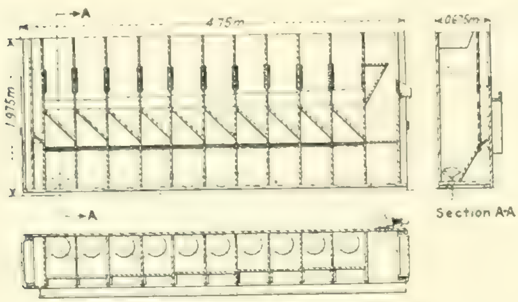
All four plants were worked by froth-flotation brought about by the entry of air from below under pressure. Oil and, exceptionally, chemicals in small amounts were added, the latter partly to assist froth formation and partly to obtain the necessary discriminating surface-tensions. In preparation the ore was reduced in wet ball-mills and tube-mills to about 120 to 200 mesh. The oil, to the extent of about 0·2 to 0·3 kilograms per ton of ore, was added in the tube-mill and the chemicals just before passing into the flotation machine. The consistency of the pulp entering these machines was a normal one for flotation.

Each Gröndal machine consists of a row of agitation boxes with narrow frothing boxes attached in front. In the bottom of each agitation box the air enters through a rose-head of large diameter under pressure sufficient to overcome the column of pulp above, this column being about 3 ft. deep. After agitation the pulp passes out of the agitation box into the frothing box through a slit situated near the top of the pulp column. From the frothing box the froth overflows into a launder over a lip the height of which is adjustable by slats, while the gangue particles sink upon a bottom inclined longitudinally in the direction of the pulp flow, being thereby directed into the next agitation chamber. The cycle then begins afresh.

As will be seen from the illustration the agitation box continues below the frothing box, and it seems likely that sand will collect above the air entry. It is not clear just how the fine division of the air is brought about. Probably the top of the rose-head is made of a porous medium or has holes in it. It is also possible that sand collected over this rose-head may assist in finely dividing the air.

Each agitation box is about 6 ft. high and about

[illegible] and with pyramidal [illegible] about 25 to 30 cu. ft. of free air per minute. In a complete machine [illegible] cells [illegible] in series and the power required for air is about 6 horse-power. [illegible] of one machine [illegible] machines, each [illegible] cells; at Friedrich-August of six machines each of 12 cells; and at Wilhelm of one machine of 12 cells. The capacity of the equipment at Gottesgabe, using only one machine (the other being held in reserve), was about 100 tons per day; that at Friedrich-August, with its six machines all in use, was about the same figure, this lower capacity being due to the fact that Rammelsberg ore carries as much as 50% of sulphides, whereas at Gottesgabe the sulphides amounted to only 6%. The results obtained at Boxbach were: A concentrate assaying 20 to 25% of copper; a tailing assaying 0·1 to 0·15%; and a recovery of 90% from a feed assaying 1·56% of copper. At the Wilhelm mine, where the ore, in addition to chalcypyrite, carried also fahlerz, pyrite, and galena, the recovery of the copper was 90% from a 2% ore. At Gottesgabe,



The Grondal Flotation Cell.

where the ore consisted chiefly of fahlerz with much iron oxide, both containing copper, the concentrate obtained assayed about 30% of copper and 4,000 to 5,000 grams of silver per ton, from a feed which averaged 1·5% of copper and 145 grams of silver; the copper in the iron oxide was not recovered.

At Friedrich-August, treating the complex Rammelsberg lead-zinc ore, the endeavour was to reduce the barite from 37% in the raw ore to about 5% in the concentrate. The following figures represent some of the results obtained:—

	Zn.	Pb.	Ag.	$BaSO_4$.
	%	%	oz.	%
Feed.........	21	11	4·5	37
Concentrate ..	34	21		5
Tailing......	4	2		86
Recovery per cent	87·5	90	90	

The author considers that though in smelting such a lead-zinc concentrate there would be considerable loss, yet in view of the removal of the barite the result might be regarded as satisfactory. In these large-scale tests several thousand tons of ore were treated and the plant is still running. The concentrate is smelted in the company's own smelter, which does not yet receive the foreign ores it did before the war.

Finally, the author is of opinion that the results obtained from this flotation process justify the hope that by it the production of base metals from German ores will be substantially increased and the oppressive dependence upon foreign ores to that extent relieved.

It may be remarked that there is no statement in this article acknowledging that flotation is a process discovered and developed outside Germany. The impression obtained by reading the article is that in the application of flotation Germany is very backward.

Inorganic Origin of Petroleum.—In the *Engineering and Mining Journal* for October 15, Hiram W. Hixon refers to the theory of the inorganic origin of petroleum, of which he is a backer. His remarks arise out of a discussion of a paper by A. G. Wolf on salt-mining in Louisiana, which was published in the issue of the Journal for July 2. Mr. Wolf gave a description of the salt domes of the Gulf Coast, and he said that the origin of these salt domes is an unsettled question, the theories of formation varying from evaporation of sea water to the intrusion of salt in a molten or plastic state.

Mr. Hixon proceeds to elaborate a new theory, as follows: The increase of temperature with depth will, at some depth moderate compared to the earth's diameter, result in a critical temperature for all matter. Thereafter all of the interior mass, below a depth of, say, 200 or 300 miles, will be in a gaseous condition, and denser than the solids that will form out of it. Gravitational compression is the cause of the density, and the conditions of equilibrium make it necessary that the interior mass shall be denser than the crust of solids which rests upon it. All known elements can be volatilized in the electric arc, which is supposed to have a temperature of about 5,000° C. With an increase of 1° C. per 100 ft. of depth, or, say, 50° C. per mile, the temperature of the electric arc would be equalled at a depth of 100 miles.

A critical temperature for any substance is the temperature above which that substance is in a gaseous condition regardless of pressure. Having passed the critical temperature of all matter, the interior mass of the earth is, therefore, in a gaseous state, and by the conditions of equilibrium, is shown to be denser than the solid crust which floats upon it. The crust floats on the gaseous interior for exactly the same reason that ice floats on water; that is, because it expanded when it changed for a gas denser than a solid to a solid, due to secular cooling. This expansion on change of state is the active cause which tears apart the cold crust in long rift cracks and furnishes a path of least resistance for volatile material in the interior to reach the surface. As expansion is in three dimensions, it follows that there should be two sets of such cracks at right angles to each other, and at the intersection of these cracks, which have been called lines of orogenic movement, the salt domes are found. The seal or cap rock is due to some elastic member of the geological section, probably shale, which will stretch under pressure without fracture. The volatile material, consisting of salt, sulphur, and petroleum, and sulphuric gases, comes up along the cracks as the path of least resistance, and being under a rock pressure equal to the depth from which it comes, is capable of making room for itself and doming up any rock mass which will not crack. The alignment of the salt domes, as shown by Mr. Wolf, is characteristic of all the others, and is explainable on the basis of the rift cracks as above described. These rift cracks, rift valleys, and graben are much more numerous than generally supposed. For example, there is a series of them in East Africa,

which is occupied by lakes extending from Lake Nyassa through Lake Tanganyika and the great Rift Valley, the Red Sea, and Dead Sea, over five thousand miles in length. In the United States there is the block faulting of the Great Salt Lake Basin, the basin of Death Valley, Yosemite Valley, and Lake Tahoe, as well as the basin of Lake Superior. The explanation of these dropped blocks is to be found in the slumping down of segments between cracks, or the dropping of wedge-shaped pieces on the sides of rift cracks. The cracks themselves are caused by the expansion of the sub-crustal material in changing from a gaseous state denser than the solid to a solid. Where there is no cap rock which will stretch without fracture, the crack extends through to the surface, and anything of a gaseous nature which comes up the crack escapes into the atmosphere, and is blown about and dissipated. The cap rock or seal above the crack is an all-important condition for the accumulation of the salt, sulphur, and oil in the salt-domes.

The process by which the salt, sulphur, and petroleum are accumulated and condensed is expressible in one word: sublimation. It is well known that salt and sulphur come from the interior and are a part of the material extruded from volcanoes, but it is not so commonly known that petroleum is also of inorganic origin. Illustrating the differences between petroleum and organic oils, whether animal or vegetable, the following list may be studied to some advantage by those who hold that petroleum is of organic origin:

(1) All organic oils, whether animal or vegetable, have both the elements of water, H and O, as a part of their composition. This makes these oils carbohydrates. The oxygen cannot be driven off unless the oil is destroyed by heat. Petroleum, on the other hand, has no oxygen in its composition, and is a mixture of hydrocarbons of the composition expressed by the formula C_nH_{2n+2}.

(2) All organic oils, and organic matter generally, are good fertilizers, and promote plant growth. Petroleum kills all plants, and is used to kill weeds and grass on roads and railways.

(3) Organic oils, both animal and vegetable, have food values for animals and men. Petroleum has no food value, and the lighter hydrocarbons, such as kerosene and gasolene, are poisonous, and are used as insecticides.

(4) All organic oils when boiled with caustic soda and potash yield soap and glycerine. Petroleum does not.

(5) Organic oils when exposed to sun and air become rancid. Petroleum evaporates, but does not become rancid.

These radical differences of composition and properties show plainly a difference of origin. If petroleum were of organic origin, it would undoubtedly have oxygen in its composition, as oxygen is inextricably connected with all processes of organic growth and decay. If petroleum were of organic origin, it would have some of the properties of organic oils, and it has none of them except an oily texture, and other things than oils have that; for example, concentrated sulphuric acid.

To deny the organic origin of petroleum demonstrates nothing; it is essential to the development of a logical theory concerning its genesis, to prove that it can be of inorganic origin.

It was found several years ago that meteorites which were freshly fallen had hydrocarbons of the petroleum type as a part of their composition. Reference to this may be found in Chamberlin and Salisbury's "Geology," in that part which deals with the planetesimal hypothesis. If the earth be conceived to be an aggregation from planetesimals or meteorites, we can at once see why it should have hydrocarbons in its gaseous interior. The hydrocarbons and many other gases would be held there by the power of diffusion, which may have placed them there originally in case the planetesimal hypotheses be not correct. As between the gaseo-molten theory or the planetesimal hypothesis there is no difference as regards the presence in the earth's interior of hydrocarbon and all other gases, including steam, for volcanic action.

Applying the theory of the origin of the salt domes and the inorganic origin of petroleum, as outlined, to the Appalachian oilfields, the following differences arise, due to the absence of "sands" in the Gulf Coast section: The salt, petroleum, and sulphur are confined to the domes or their immediate flanks. In the Appalachian oilfields the rift cracks end in "sands," which are porous and allow the oil, gas, and salt-water to spread out laterally under large areas covered by an impervious blanket seal of shale, which has stretched under the pressure of the overlying rocks and prevented the cracks from extending further upward. The oil and gas spread from the rift crack source laterally, and not up the flanks of the anticlines or toward the centre of a dome, as supposed by the advocates of the organic theory. The anticlines and domes are also the direct result of elevation by reduction of density due to the local accumulation of leavening gases and light material. In fact, the cart has been placed before the horse, and effect has been mistaken for cause. The domes and anticlines are not the cause of the accumulation of oil and gas, but the effect of that accumulation over the rift cracks, which are invisible, but none the less there.

SHORT NOTICES

Mine Ventilation. — At the meeting of the Institution of Mining and Metallurgy held on October 27, Dr. Leonard Hill presented a paper on "Ventilation and Human Efficiency."

Decay of Mine Timbers.—In the *Engineering and Mining Journal* for October 8, Daniel Harrington writes on the decay of mine timber in return air courses, and methods of prevention.

Nordberg Winding Engine. — *Engineering* for October 21 describes and illustrates the Nordberg compound winding engine at the Homestake mine, South Dakota.

Conveyors.—At the meeting of the Newcomen Society, held on October 12, G. F. Zimmer read a paper on the history of continuous conveying devices. An abstract of the paper is given in *The Engineer* for October 14.

Air-Compressor.—*Engineering* for October 14 contains an article describing a 6,400 cu. ft. air-compressor, made for the New Modderfontein gold mine by Belliss & Morcom, Ltd., of Birmingham.

Mine Pumps.—In a paper read before the South Staffordshire and Warwickshire Institute of Mining Engineers held on October 10, S. H. Cashmore gave particulars of the Feuerheerd pump for use in mines.

Mine Sampling.—In the *Engineering and Mining Journal* for October 1, B. G. Anderson describes the sampling method employed at the disseminated copper deposits at Tyrone, New Mexico, belonging to the Phelps Dodge Corporation.

Dredging Efficiencies.—In the *Engineering and Mining Journal* for October 22, C. W. Gardner contributes an article on drilling results and dredging returns.

Prospecting.—In *Economic Geology* for August, Augustus Locke writes philosophically on "ore-finding."

Copper Leaching.—In the *Mining and Scientific Press* for October 15, Joseph Irving describes the copper-precipitation process and plant at Copper Canyon, Nevada.

Zinc Smelting.—In the *Engineering and Mining Journal* for September 10, Evans W. Buskett wrote on the smelting of zinc ores in a blast-furnace under pressure. In the issue of October 15, B. M. O'Hara gives a bibliography of the subject, showing that previous experiments had shown the idea to be incapable of application.

Ferro-Vanadium.—The *Journal of Industrial and Engineering Chemistry* for October contains a paper by G. L. Kelley and others on the determination of vanadium and chromium in ferro-vanadium by electrometric titration.

Archæan Sulphides of Sweden and Finland.—In *Economic Geology* for August, Per Geijer writes on the Archæan sulphide ores of Sweden and Finland, noting particularly the Orijarvi district in South-west Finland. The term Fenno-Scandia has recently been proposed for the geological region comprising the Scandinavian peninsula and Finland.

Gold Deposits in British Guiana.—In a paper presented at the meeting of the Institution of Mining and Metallurgy held on October 27, J. N. Justice described the geology of a gold deposit on Eagle Mountain in British Guiana, near the confluence of the Potari and Essequibo Rivers.

Bolivian Tungsten. — The *Engineering and Mining Journal* for September 24 reprints a paper by F. L. Hess, presented at a meeting of the Society of Economic Geologists, describing tungsten deposits in Bolivia.

Tin in China.—At the meeting of the Institution of Marine Engineers held on October 11, W. Semple read a paper on the mining and treatment of tin ore in Kotchiu, Yunnan.

Almaden Quicksilver Mine. — In *Economic Geology* for August, Courtenay De Kalb describes the Almaden quicksilver mine, Spain, and F. L. Ransome writes on the ore of this mine.

Borax in Nevada.—In the *Engineering and Mining Journal* for October 1, Hoyt S. Gale describes the newly discovered colemanite deposit at Callville Wash, Clark County, Nevada.

Oil in Guatemala. — In the *Engineering and Mining Journal* for October 1, A. H. Redfield discusses the possibilities of finding petroleum in Guatemala.

Oilfield Losses.—At the meeting of the Institution of Petroleum Technologists held on November 8, A. Beeby Thompson read a paper on the Elimination of Oilfield Losses.

W. J. Loring.—The *Engineering and Mining Journal* for October 15 gives a biographical sketch of W. J. Loring.

L. D. Ricketts. — The *Mining and Scientific Press* for October 1 contains an account of an interview with Dr. L. D. Ricketts, written by T. A. Rickard. Dr. Ricketts is known in connection with his mining and metallurgical work at copper mines in Arizona and Sonora.

RECENT PATENTS PUBLISHED

☞ *A copy of the specification of any of the patents mentioned in this column can be obtained by sending 1s. to the Patent Office, Southampton Buildings, Chancery Lane, London, W.C. 2, with a note of the number and year of the patent.*

7,663 of 1920 (169,188). Scovill Manufacturing Co., Newhaven, Connecticut. Electric melting furnace for copper and other non-ferrous metals.

8,359 of 1920 (168,927). E. Edser and L. A. Wood, London. A process for the concentration of ores, particularly those containing cassiterite or wolfram together with colloidal metallic oxides, such as those of iron and aluminium, which consists in mixing the finely pulverized ore with water, preferably soft water, adding a deflocculating agent, such as sodium silicate or silicic acid salt, thus freeing the particles from one another so that certain ore particles will sink, while the said colloidal particles remain in suspension, removing the suspension from the settled product and subjecting the latter to treatment by a flotation process.

12,368 of 1920 (168,627). A. H. Eustis, Norfolk, Massachusetts. Improvements in the method of removing sulphurous acid from smelter smoke by dissolving in water and afterwards recovering by the action of heat and vacuum.

14,800 of 1920 (144,278). United Filters Corporation and E. J. Sweetland, New York. Improvements in the construction of pressure filters of the leaf type.

14,885 of 1920 (146,939) and 15,732 of 1920 (146,942). W. E. Trent, Washington. In the smelting of ores, introducing them into the furnace in a fine state of division together with reducing gases, and introducing at the same time jets of water to be used partly for controlling the temperature, and partly as a reagent; also methods of collecting the products of reaction.

14,944 of 1920 (168,643). P. Danckwardt, Denver. Method of producing anhydrous aluminium chloride, particularly for recovering this compound used in the production of petrol from mineral oils.

15,121 of 1920 (144,306). American Smelting and Refining Co., New York, and G. C. Howard, Tacoma. Method of producing elemental sulphur from sulphurous acid recovered from smelter smoke by passing the acid gas mixed with air through incandescent coke.

15,122 of 1920 (168,420). American Smelting and Refining Co., New York. Machine for stacking bars and slabs of metal coming from the casting machines.

15,356 of 1920 (168,429). A. R. Mangnall, Chester. Improvements in the inventor's machine for boring through soft earth without removing the earth.

15,519 of 1920 (168,434). J. W. Moffatt and W. F. Sutherland, Toronto. Furnace for reducing metals from oxide without fusion, and subsequently melting the product electrically.

15,646 of 1920 (168,977). W. C. Heraeus Co., Hanau, Germany. Method of securing purity and regularity of characteristics of certain metals

used in the manufacture of thermo-couples for pyrometers.

16,017 of 1920 (167,917). J. ADAIR, Taunton. Construction of heated chambers for drying china clay.

16,461 of 1920 (145,431). ANSCHÜTZ & Co., Kiel. Method of keeping vertical bore-holes in true alignment.

16,495 of 1920 (145,433). W. BREIL, Essen. Method of constructing concrete shaft-linings which will be water-tight.

16,586 of 1920 (169,247). E. E. NAEF, Nottingham. For the production of metallic nickel and nickel salts, the treatment of finely divided nickel sulphides with solid caustic alkalies, or mixtures thereof with any or all of the following substances: Sodium carbonate, common salt, sodium sulphate, sodium sulphide, calcium oxide and hydroxide, at fairly low temperatures, 250° to 600° C.; with or without the addition of finely divided coal, and in presence or absence of hydrogen or gases containing such, or in presence of both coal and hydrogen.

17,092 of 1920 (169,288). E. W. WILKINSON, New York, and MINERALS SEPARATION, LTD., London. Method of producing frothing agents suitable for the flotation process by subjecting certain organic substances such as kerosene, to a partially decomposing heat in the presence of air.

17,765 of 1920 (169,301). HOYANGSFALDENE NORSK ALUMINIUM CO., Christiania. Process of producing alumina from clay, characterized by the combination of the operations of decomposing a potash-bearing clay with sulphuric acid, lixiviating the decomposition product, precipitating potash alum from the solution, decomposing the potash alum by heating, whereby potassium sulphate and alumina are obtained, separating the potassium sulphate from the alumina by lixiviation, recovering potassium sulphate from the solution, and adding a portion of the potassium sulphate to a sulphate solution obtained by decomposition of a further portion of potash-bearing clay.

18,179 of 1920 (145,789). G. BONNARD, Plombiere St. Michel, Savoy, France. Process for refining tin and antimony by the action of dry chlorine on the crude metal, so obtaining anhydrous liquid chlorides.

18,398 of 1920 (146,410). C. CLERC and A. NIHOUL, Paris. Manufacture of pure zinc sulphide by the action of hydrogen sulphide upon a slightly acid solution of a zinc salt with addition of magnesia or an appropriate magnesium salt such as magnesium carbonate in such proportions as to allow a small proportion of acid to remain free in the solution at the end of the operation.

19,159 of 1920 (168,479). G. R. BROWN, Sydney. Machine for electrostatically separating finely divided ores.

19,956 of 1920 (147,903). METALLBANK UND METALLURGISCHE GESELLSCHAFT, Frankfort. Use of lithium for alloying with aluminium to increase its mechanical strength.

20,023 of 1920 (148,122). L. HACKSPILL and C. STACKLING, Strasbourg. Manufacture of sodium and other alkali metals by the reaction between the chloride of the metal and calcium carbide, conducted dry under considerable heat.

20,170 of 1920 (148,242). CHEMISCHE FABRIK RHENANIA and G. A. VOERKELIUS, Stolberg. Compound fertilizer made by the action on phosphate of nitric acid and potassium sulphate.

21,033 of 1920 (149,247). J. SIMON, Frankfort. A process for the chloridizing-roasting of burnt pyrites, wherein the material, mixed with salt and with less than 2% of coke breeze, is roasted on the counter-current principle in an air-tight stationery shaft, by means of air under pressure passing upwards through the apparatus, while the completely roasted material is mechanically removed.

21,921 of 1920 (168,497). J. & E. WRIGHT, LTD., and J. W. A. RULE, Birmingham. A pocket clinometer and caliper gauge combined, suitable for measuring the inclination of ropes, their diameter, and the depth of pulley grooves.

26,091 of 1920 (168,781). F. PRATT, Treherbert, Glamorgan. A safety device for automatically applying the brake to winding engines.

27,132 of 1920 (168,731). W. H. BOORNE, London. Furnace for oxidizing tin.

29,215 of 1920 (153,297). FARBENFABRIKEN F. BAYER, Cologne. Precipitating sulphur from sulphuretted hydrogen by mixing with air and precipitating on porous carbon.

NEW BOOKS, PAMPHLETS, Etc.

☞ Copies of the books, etc., mentioned below can be obtained through the Technical Bookshop of *The Mining Magazine*, 724, Salisbury House, London Wall, E.C. 2.

Some Principles Governing the Production of Oil Wells. By CARL H. BEAL and J. O. LEWIS. Bulletin 194, published by United States Bureau of Mines.

Underground Conditions in Oilfields. By A. W. AMBROSE. Bulletin 195, published by the United States Bureau of Mines.

Silver Ores. By H. B. CRONSHAW. Paper covers, 152 pages. Price 6s. net. Prepared under the direction of the Mineral Resources Committee of the Imperial Institute. London: John Murray.

Petroleum. Paper covers, 110 pages. Price 5s. net. Prepared under the direction of the Mineral Resources Committee of the Imperial Institute, jointly with His Majesty's Petroleum Department, with the co-operation of H. B. Cronshaw. London: John Murray.

Detection and Estimation of Platinum in Ores. By C. W. DAVIS. Technical paper 270, published by the United States Bureau of Mines.

Flotation Tests of Idaho Lead-Zinc Ores. By C. A. WRIGHT, J. G. PARMELEE, and J. T. NORTON. Bulletin 205, published by the United States Bureau of Mines.

Mica, Bauxite, Borax, Corundum, and Garnet. By Dr. J. COGGIN BROWN. Being Bulletins 12 and 15 on Indian Industries and Labour, issued by the Government of India. London: India Government's Department of Commerce and Industry, 60, Winchester House, E.C. 2.

Geology of the Diamond-bearing Gravels of the Somabula Forest. By A. M. MACGREGOR. Bulletin 8 of the Geological Survey of Southern Rhodesia.

COMPANY REPORTS

Chenderiang Tin Dredging.—This company was formed by Bright & Galbraith, Ltd., in 1914, to acquire alluvial tin ground in Chenderiang Valley, Perak, Federated Malay States. A bucket-dredge started work in April, 1915. The report for the year ended March 31 last shows that the dredge treated 965,000 cu. yd. of ground and extracted 339 tons of tin concentrate, the yield averaging 0·79 lb. per yard. The output from the hydraulic

[illegible] and from tributers was 104 tons, so that the total output was 443 tons. The company's income was £50,406, and the net profit was £5,251, out of which £3,727 has been applied to the extinction of the balance of the development account.

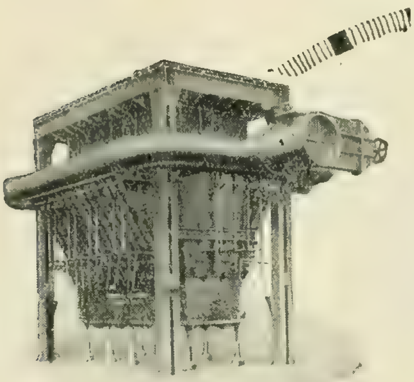
Ipoh Tin Dredging. This company was formed in 1913 to acquire alluvial tin property at Lahat, in the Kinta Valley, Perak, Federated Malay States. A bucket-dredge started work in August, 1915, and two more dredges were ordered later. The company is controlled by the Borneo Company, Ltd., and L. G. Attenborough is the manager. The report now issued covers the fifteen months ended March 31 last. During this time 656,700 cu. yd. of ground was treated, for a production of 215 tons of tin concentrate, being a yield of 0·73 lb. per yard. The amount of ground treated was below normal, owing to the limestone pinnacles being high and also owing to the inefficiency of the pumps. On the other hand the yield per yard was considerably higher than during 1919. The accounts show an income of £37,036 from the sale of tin concentrate, and an adverse balance of £1,429. Further information is given in the Review of Mining.

Consolidated Gold Fields of New Zealand.—This company was formed in 1896 to acquire from the late David Ziman certain gold-mining properties in the Reefton district of New Zealand. The company floated off the Progress and Blackwater properties as separate companies, and continued to work the Wealth of Nations mines itself. The Wealth of Nations was closed in 1918, owing to a fire. The report for the year 1920 shows that the mine has been drained and partly repaired, but that a resumption of operations is not yet possible. The ore reserve remains as reported at the end of 1919, namely 16,044 tons, averaging 11·58 dwt. gold per ton. The accounts show a loss of £12,108 for the year. As the year commenced with a credit balance of £19,476, the year ends with a credit balance of £7,368. **Progress Mines.**—Mining operations were suspended at the end of August, 1920, as the results of development above the 11th level were not promising. When economic conditions allow, it is intended to sink deeper. During the eight months from January to August, 1920, the amount of ore raised was 8,102 tons, from which gold worth £12,619 was extracted. The working cost was £15,509, leaving a working loss of £2,889. **Blackwater Mines.**—The amount of ore treated during the year was 24,468 tons, yielding gold worth £58,607 The working cost was £45,317, leaving a working profit of £13,290. Development continues to give satisfactory results, and at the end of the year the reserve was estimated at 86,600 tons, averaging 8·47 dwt. per ton.

Broken Hill South.—This company was formed in 1893 to work silver-lead-zinc deposits at the south end of the Broken Hill range, New South Wales. Operations were suspended from April, 1919, to November, 1920, on account of labour troubles. In July, 1919, a large part of the surface plant was destroyed by fire, and the time from then until the end of the strike was occupied in the work of reconstruction. The report now issued covers the year ended June 30 last. This records that the flotation plant treating dump slime was restarted on November 15, 1920, mining operations resumed on December 20, and one section of the reconstructed concentrating plant put to work on January 24, 1921. On January 25 the smelting plant of the Broken Hill Associated Smelters at Port Pirie suffered serious damage by fire, so it was not possible to send the lead concentrates thither for treatment. The Sulphide Corporation, however, undertook to treat a limited amount of these concentrates, along with similar concentrates from other mines, at the Cockle Creek smelters. From March 2 to 29 operations ceased at the mine and mill on account of coal shortage, but from the latter date operations have been continued on the basis of half-time one-shift per day. During the period covered by the report, 37,923 tons of ore was raised from the mine and sent to the concentrators, where the following products were obtained: 5,981 tons of lead concentrate averaging 63·4% lead, 8·6% zinc, and 27·3 oz. silver per ton; 24,667 tons of zinc tailing, averaging 17·3% zinc, 3·6% lead, and 4·3 oz. silver; and 5,682 tons of slime averaging 13·2% lead, 14% zinc, and 10·3 oz. silver. The current slime was treated for lead, producing 1,027 tons of concentrate, averaging 54·7% lead, 10·9% zinc, and 45·6 oz. silver; the zincy residue averaging 14·7% zinc, 4% lead, and 2·6 oz. silver. There was also treated 54,864 tons of dump slime, averaging 11% lead, 13·4% zinc, and 7·9 oz. silver, for a yield of 7,299 tons of lead concentrate averaging 47·2% lead, 15·1% zinc, and 41·2 oz. silver; the zincy residue averaging 13·2% zinc, 5·4% lead, and 2·7 oz. silver. The zinc tailing (other than slime) obtained from the treatment of the crude ore, 24,667 tons (as before mentioned), was delivered to the Amalgamated Zinc (De Bavay's), and 158,908 tons of dump tailing, averaging 16·9% zinc, 6% lead, and 3·9 oz. silver, was delivered to the Zinc Corporation. The accounts show a loss of £56,701, and in addition £55,207 was written off for depreciation of plant, and £13,333 was allowed for debenture redemption, provision for these two items coming from the reserve fund. The ore reserve remains at 3,500,000 tons, as no great amount of development has been possible lately.

North Anantapur Gold Mines.—This company was formed in 1908 by John Taylor & Sons, as a subsidiary of the Anantapur Gold Field, Ltd., for the purpose of working old gold mines in Madras Presidency, India. Milling commenced in 1910. Additional capital was raised in 1911 by the issue of preference shares for the purpose of increasing development. The scale of operations and profits was never large. Four years ago developments began to give poor results, and the output has decreased ever since. The report for the year ended June 30 last shows that 8,800 tons of ore was raised and treated in the stamp-mill for a yield of 9,977 oz., and that 9,800 tons of sand and slime yielded 965 oz. In addition 357 oz. was obtained by re-treatment of dump material, bringing the total yield to 11,299 oz. This gold was sold for £61,823, of which about £13,000 represented premium. The working profit was £30,354, out of which £14,374 has been distributed as dividend, being at the rate of 27½% on the £25,000 preference shares, and 7½% on the £91,253 ordinary shares. Mining operations during the year have not resulted in the discovery of any further ore-bodies of value and the reserve at June 30 was only 7,000 tons. There remains 40,000 tons of sand on the dump to be re-treated. In all probability mining operations will have to cease shortly. The company has interests in copper deposits in the Chota Nagpur district, which are now being investigated.

Mining Machinery



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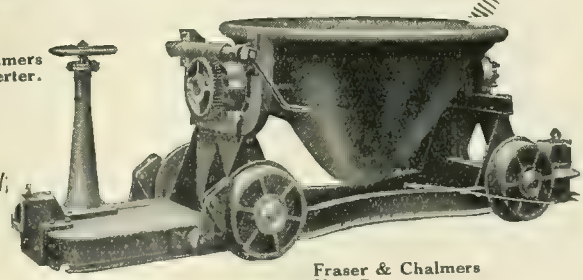

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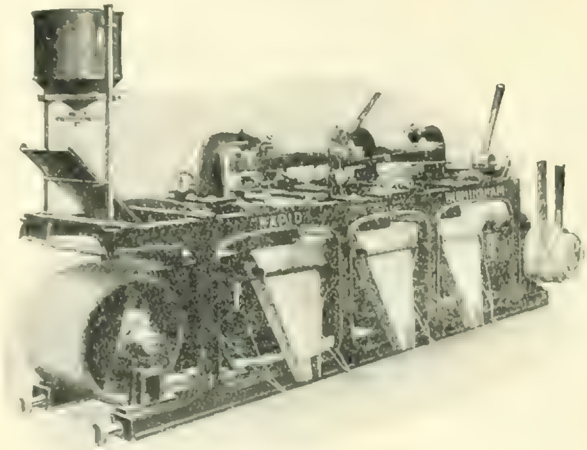

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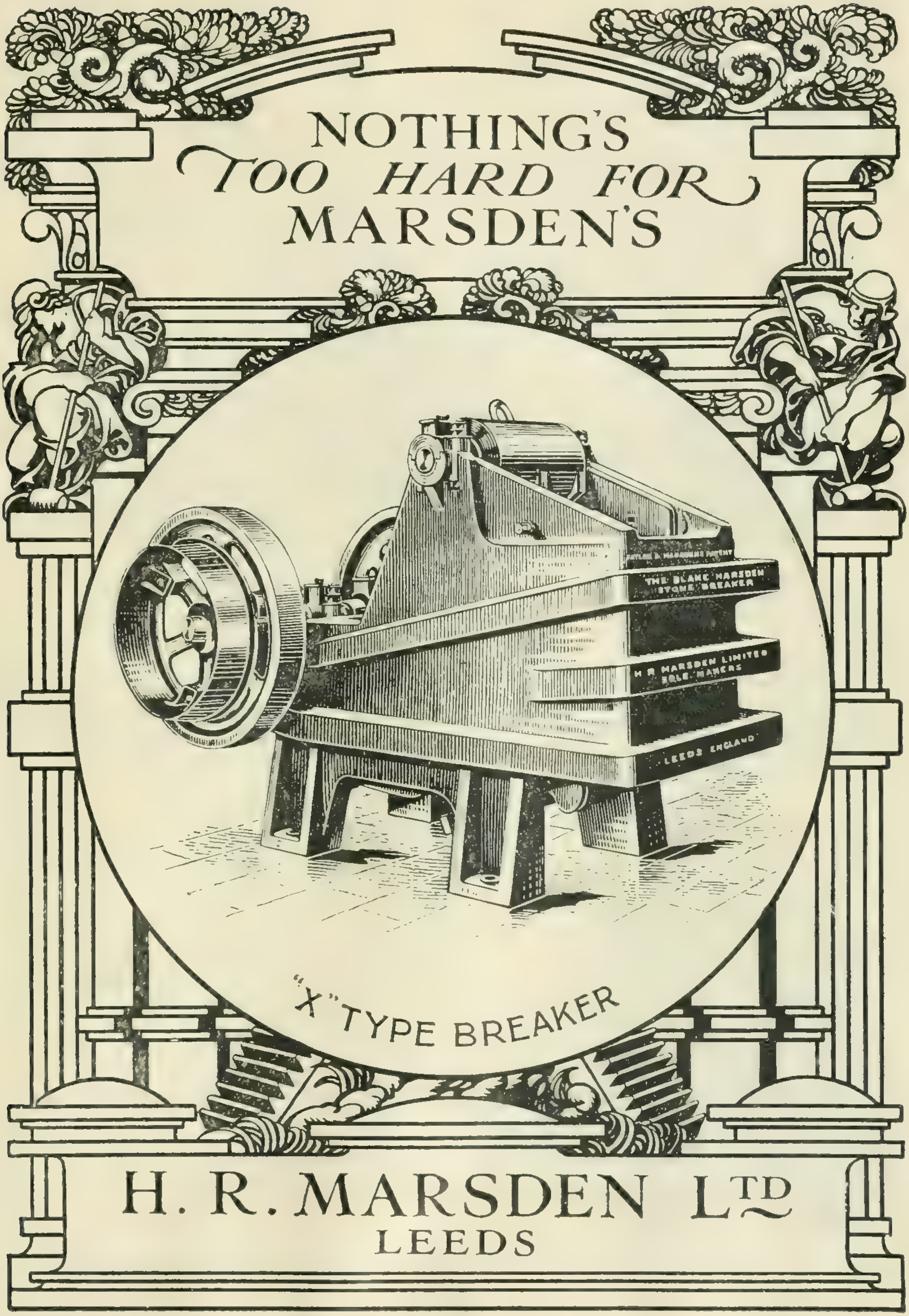
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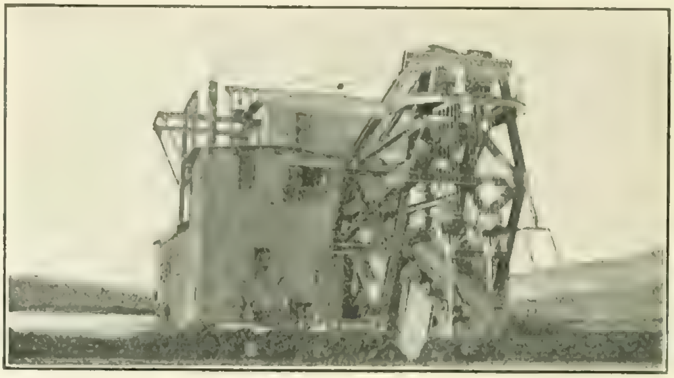

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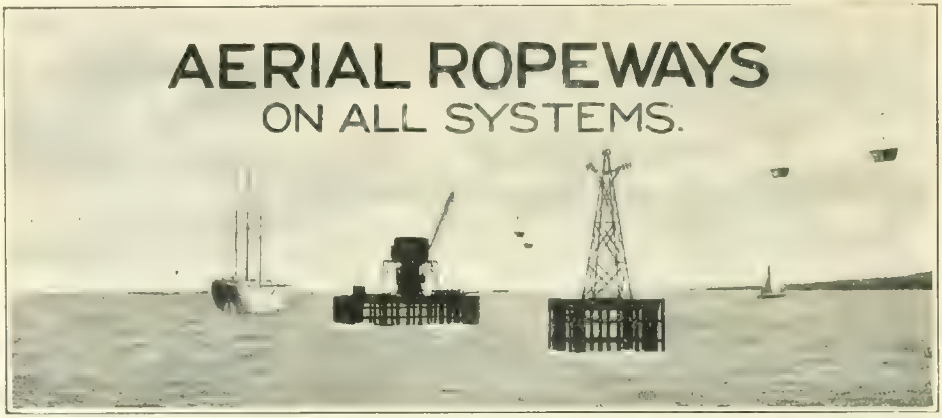

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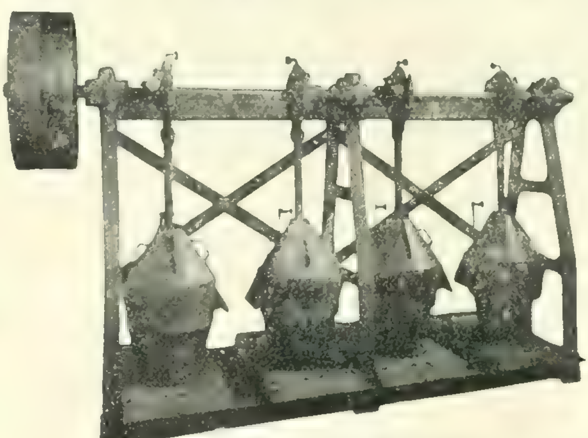

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EDITORIAL

Memorials to the Dead

On November 24, Field-Marshal Earl Haig unveiled the Memorials erected in the honour of the members, associates, and students of the Institution of Mining and Metallurgy, and of the members of the Institution of Mining Engineers who fell in the Great War.

After brief introductory remarks by Mr. F. W. Harbord, president of the Institution of Mining and Metallurgy, and by Colonel W. C. Blackett, president of the Institution of Mining Engineers, Earl Haig said :—

" Two good reasons urged me to accept your invitation to come here to-day to unveil these two Memorials to your gallant dead.

" The first, and more general one, is that on all such occasions I am able to pay personal tribute to a section of those many thousands of brave men who fought under my command in France, and under my command paid the last and greatest sacrifice that love of King and Country can demand of true and loyal citizens.

" The least that I can do, I, who acting myself in the execution of my duty, asked and obtained so much from them in the execution of theirs, is to join with those who knew and loved them in honouring their names.

" My second and more particular reason for wishing to come here is that you afford me the opportunity to say a few words of especial thanks to a body of men whose work in France seldom drew upon itself much notice or glory at the time ; but was surpassed by none in the demands it made upon the skill, courage, and resolution of the individual concerned or in the service it rendered to the Army as a whole.

" One thinks naturally of the battle of Messines, and of the mighty series of explosions that tore great gaps in the German line on June 7, 1917, and gave the signal for one of our most successful attacks. That was the work of the special services to which you sent so many gallant men ; and it was indeed a signal triumph of British mining in war. Yet few, I think, outside those who took part in the work or saw and benefited by its results, realize the immense amount of steady and persistent toil, in every circumstance of peril, surrounded by danger in a form that might well appal the stoutest-hearted, that went to the preparation of that triumph. Few, I know, realize how vast and how important to the safety, comfort, and success of our troops, was the other work of our miners ; work that was little commented upon in the Press, but yet went on steadily and continuously day after day and year after year all along the British front.

THE MEMORIAL ERECTED BY THE INSTITUTION OF MINING ENGINEERS.

" There was no truce at any time to the warfare that went on underground ; no respite from the toil that the needs of the Army imposed upon those who were the masters

of the art of digging underground. Only, there were periods of redoubled activity, or more than common strain. Every offensive undertaken by us, right up to the days of the last great series of advances, meant a fresh call upon the energy, industry, and courage of these special services upon whom the due preparation of those offensives so largely depended. Tunnelled approaches had to be constructed for great distances, dug-outs built for headquarters, dressing-stations, and shelter generally. Every big offensive made demands of this kind. An immense amount of work was done for the Somme. The preparations for the battle of Arras attracted little attention compared with those for the Messines battle, but were no less valuable. Then, later, when the day of the elaborately mounted attack was over, the tunnelling companies found a new work, hardly less arduous or dangerous, in the discovery and removal of many thousands of German mines.

"I am talking to those who themselves know something of these things; but it is right that others should know, too, and here where you are met to pay a last honour to comrades, members of your Institutions who actually accomplished these things and died nobly in the doing of them, I am glad to thank anew—not for myself only, but on behalf of the whole Army—a most gallant body of men.

"This is an occasion for deep sympathy with those who have lost so much and see in these memorials the commemoration of their private sorrow. It is an occasion, too, for admiration and gratitude towards men who gave so much, all that men could give, for the liberty and honour of their fellow-countrymen. It is more even than that. It is an occasion for us who remain to take courage from the example of those who have so bravely gone before us. The cause for which these honoured dead gave the last full measure of their devotion is still ours to uphold. The task to which they gave their lives is laid upon us and our children to complete.

"Therefore as days go by we should look upon these memorials with quiet sorrow, but with lasting pride. They should be to us lessons not only of what men have done, but of what true men can do. Then shall we and generations to come after us draw hope and inspiration from the memory of what these men accomplished in the strength of their faith and patriotism. So that in the days of difficulty, now and hereafter, the great commonwealth of nations to which we all belong, which we all love, shall never lack for men who will—as did these whose names are here written—count their own lives as nothing in their country's service."

THE MEMORIAL ERECTED BY THE INSTITUTION OF MINING AND METALLURGY.

The Memorials are installed in the library of the new house of the two institutions in City Road. That of the Institution of Mining Engineers consists of a mural plaque of marble, on which is a draped female figure in bronze. Underneath is a bronze plate bearing the dedicatory inscription, and on the marble are carved the names of the fallen. The rising sun about the base of the figure is done in gold mosaic. The sculptor was

Mr. Allan G. Wyon. The Memorial erected by the Institution of Mining and Metallurgy was designed and executed by Lieut.-Col. Peter N. Nissen, a member of council of the Institution. Colonel Nissen's idea was to portray the work done by the tunnellers, and the main figure represents a second-lieutenant in the act of exploding a mine. For the purpose of description of this memorial we cannot do better than quote some verses written by a visitor who was present at the unveiling ceremony.

THE MEMORIAL
erected by the
INSTITUTION OF MINING AND METALLURGY
TO THEIR GLORIOUS DEAD.

Would they, the brave ones early dead and gone,
Desire that we should carve their names in stone,
Erect memorials in their honour, and
Inscribe their deeds upon the roll of fame ?
With humble self-effacement they might say
That they did not regret the sacrifice,
They only fought for duty, not for praise,
That those who fought and lived deserve
An equal recognition ; or they might
Prefer the glory to be given to Him
Who sent them strength and heart to lay the foe
And so preserve the freedom of the world.
Thus is the monument designed to show
The work the miners did throughout the war,
That both their friends and those who follow on
Shall look on it with thankfulness and pride.
To render glory unto God we need
No sculptured figure with symbolic aim ;
Sufficient is the record of good deeds,
Portrayed by deft and reverential hands.
But best of all to please both dead and quick
Is that the monument should be designed
By one who was himself upon the field
And could present the actual scenes of war.
High on a pedestal of malachite
Stands a young officer of engineers,
With strained attention ready to explode
The charge and force the climax of attack ;
The boots, the mud, the sand-bags, and the tins
Show the environment in which he worked.
The sculptor has recorded other scenes,
Familiar to the miner in the war,
In bas-relief in panels 'neath the plinth ;
Field and machine guns, scouting aeroplanes,
A Flanders road with all its trees destroyed,
A bridge to span a Belgian waterway,
A tunneller listening with the geophone,
A warship, and a poison chemist's den ;
The habitations on the firing line
In which the men took cover or sought rest :
The unseen hut, the dug-out, and the house
Battered by shell and falling to the ground.
On silver plates are cut the names of those
Who died, with glowing words of true regret.
The bronze, the malachite, the silver, all
Suggest the missions of the fallen men
Before the battle called them to the front.
Complete it stands upon a base of oak,
Oak, British oak, that still denotes the strength
And steadfastness of Britain's sons.
Farewell ! Yet not farewell, ye noble dead,
Your name shall surely live for evermore !

The Huelva Rocks and Ores

The paper read by Mr. Henry F. Collins before the Institution of Mining and Metallurgy on November 17, entitled "The Igneous Rocks of the Province of Huelva and the Genesis of the Pyritic Ore-bodies," is an important contribution to the study of the economic geology of that celebrated mineral region. The problem of unravelling the nature and sequence of the great variety of igneous rocks found there and the origin of the ore deposits has never received the attention of the mining companies working in the South of Spain in the way it deserved. The reason for this neglect is to be found in the fact that the ore-bodies are too large and continuous to require the aid of science in their discovery. It was rather the problem of dealing with the ores, from the standpoint of the metal and chemical industries, that called for close study of the companies. In other words, it was the destination, not the origin, of the ores that absorbed attention. The chief literature on the subject hitherto published has come from Spanish, German, Swedish, and French geologists, of whom Gonzalo Tarin, Vogt, and Klockmann are the best known ; and in the early days the only contributions of note coming from an Englishman were those by the late Mr. J. H. Collins, father of the present author. Some of these writers took the view that the deposits were of sedimentary origin contemporaneous with the enclosing slates ; others that they were formed by magmatic segregation from the igneous rocks ; while the Spanish and French geologists mostly adhered to the view that they were in the main vein deposits formed by ascending solutions. Of geologists with more modern ideas who have visited Huelva province, the first to write a convincing account of the rocks and ores was the late Dr. A. M. Finlayson, then a student at the Royal School of Mines. Finlayson was a young New Zealander, and he undertook, while at South Kensington, the petrographic study of a number of mineral districts for the purpose of winning his D.Sc. of London. It is a remarkable circumstance that he should have grasped the meaning of the Huelva rocks and ores in so short a time, and that so young a man should write a paper that almost immediately was accepted as a classic. His untimely death early in the war was regretted by all who knew him, for it is clear that mining geology thus lost one who promised to become

an exponent of the highest rank. His work at Huelva was confined to only one part of the mineral zone, and some of his conclusions, of minor importance, were based on incomplete data; but in spite of this drawback his exposition of the geology of the district is nowadays universally taken as a convenient basis for the study of these rocks and ores.

The paper written by Mr. Henry F. Collins represents the results of his detailed investigations during the eight years of his management of the Huelva Copper and Sulphur Company's group of mines. His intention was to prepare a geological map of the whole mineral province, but his limited leisure during mine management and the extraordinary complexity of the rocks combined to make it impossible for him to complete his task before leaving Spain. He had, however, collected a vast amount of evidence which enabled him to draw certain conclusions with regard to the nature of the rocks, and the history of the ore-bodies. This evidence and his arguments based thereon form the substance of the present paper. Extracts from the paper are given in the Mining Digest elsewhere in this issue.

Mr. Collins's evidence generally confirms Finlayson's main conclusions, but in some cases his new evidence tends to modify them in detail. He entirely confirms Finlayson's conclusions as to the origin of the ore: "The ore-bodies are in the main replacements of zones of rock, which, owing to crushing and shearing, or to other causes, was specially permeable to the passage of mineralizing solutions." Mr. Collins adds to this general conclusion that the ore-bodies are sometimes replacements, not merely of the crushed and sheared zones of a particular rock, but also of narrow residual belts of slate or schist that had become enclosed between two similar or dissimilar dykes of igneous rock; and that replacement has occurred in many instances at a contact between slate or schist and igneous rock; moreover, that there is plenty of evidence of the gradual replacement of rock by ore, particularly in the schists, where the banded structure is still preserved.

An interesting part of the paper is that in which Mr. Collins advances theories to account for the various enrichments of copper in the pyrites, in addition to the theory of secondary enrichment already well known. As the enrichments referred to by Mr. Collins took place during the formation of the deposits or shortly afterwards, he calls them "primary" enrichments. He divides them into two classes, those coming from deep-seated sources, and those coming in laterally. As regards the former, he holds that, as the circulation of the mineralizing solutions became less violent owing to cooling and to the local cessation of earth movement, the solutions became relatively more highly charged with copper than with iron, and produced local primary impregnation in the pyrites already deposited. As to the latter, he believes that an enrichment with chalcopyrite has in many cases been effected through the infiltration of solutions laterally from the dykes of diabase and porphyry which so frequently run parallel to the lodes at a short distance from them. These theories, especially the latter, have helped in locating the parts of the ore deposits richest in copper, and therefore deserve serious consideration.

There are one or two other points in connexion with Mr. Collins's paper to which attention may be drawn. One is his implied protest against the recommended abandonment of the term "diabase" by the committee of British petrographers. A second is the author's analysis of the rocks for pyrites and chalcopyrite, which shows the remarkably regular presence of these minerals throughout the igneous rocks and slates. The full significance of the condition thus revealed is by no means clear; at any rate, it is on a par with the results obtained by Lincoln and others that gold and silver are to be found in all igneous rocks. It would appear to confirm Mr. Collins's theory of lateral primary enrichment. A third item of note is the author's statement that throughout the various igneous masses signs of contact metamorphism are by no means plentiful. This revives the query that has often been given a place in our pages as to the possibility of molten matter passing through solid rock without affecting its surface in any way; but this is too big a subject to broach on this occasion.

Rhodesia Broken Hill Fossils

The Rhodesia Broken Hill mine is not only noted for its ores containing lead, zinc, and vanadium, but it has provided many interesting studies for the zoologist owing to the immense collection of animal remains found in the caves. Some years ago Messrs. Franklin White and F. P. Mennell wrote of the discoveries here. Cave-hunting

provides the romance of geological study, and in this country the limestones of Yorkshire and Durham have become famous in this connexion. At Rhodesia Broken Hill the caves have yielded fossils for years, and many of these have been sent to the Natural History Museum at South Kensington, but hitherto the bones discovered have been the remains of animals closely related to those that now live in the district. The importance of these caves has jumped suddenly to the front by the discovery of a skull of a prehistoric man. This was uncovered by Mr. W. E. Barren, a member of the staff of the company, and it was brought to London by Mr. Ross Macartney, the manager. It now lies at the Natural History Museum, where it is attracting the attention of the zoological savants. Communications relating to its antiquity have appeared in the *Times* and *Nature*, emanating from Dr. Smith Woodward, Dr. Elliott Smith, Sir E. Ray Lankester, Sir Arthur Keith, and others. These authorities agree that the skull belonged to a being combining human and ape-like characteristics, but far nearer to any modern type of man than to the ape. Comparisons are made between this skull and those discovered at Piltdown, in Java, in South Africa, and in the caves of Belgium and France, and as far as can be gathered the judgment is that the Rhodesian skull belongs to a new type and is perhaps later than the others named.

James Wickett

The late Mr. James Wickett, who died at his home at Redruth on November 12, at the the age of 79, was one of the best friends of metalliferous mining that ever lived, from the points of view alike of the professional man, the miner, and the investor. He never claimed to be brilliant and never aspired to be smart, but he had a sound knowledge of the business of mining, and a conscientious and altruistic method of dealing with the three classes of people connected with this industry. He was always an optimist, but never allowed his natural inclination to believe in and hope for the best to bias his judgment. The object of his investments in mining was to reap a reward in the way of dividends earned by extracting metals from the ground, not to seek to create a boom in his shares and unload on his clients and the public; and all his recommendations as regards purchases of shares were based on the same lines. His clients looked for the profits out of dividends and from the capital appreciation of their holdings arising solely from the intrinsic worth of the mines. He had no parent financial company to float and control his Malayan group of tin mines, so that shareholders were not saddled with big promotion and agency expenses and commissions, and the market for the shares in the mining companies was free and not influenced by the Stock Exchange requirements of such a parent company. The working costs at the mines were always kept within reasonable limits, and the charges for administration at the home offices were, we almost might say, ridiculously low. In this policy he was well backed by the engineers, with whom he was so long associated.

At the meetings of the companies of which he was chairman he many a time gave reminiscences of his early experiences. He used to tell how his father made money out of Tincroft in its palmy days, and that he was indebted for his liberal education to the funds thus made available. Then he told of his first business engagement with Mr. J. M. Williams, of Gwennap, and of his position as confidential agent with Williams, Foster & Co., of Swansea. For forty-two years, up to the time of his death, he conducted a stockbrokers' business at Redruth, most of the time being associated with Mr. Samuel Abbott, and latterly with his sons, Mr. Tom Wickett and Mr. Stanley Wickett.

It is about thirty years since the firm of Osborne & Chappel, of Ipoh, Perak, approached him with the view of obtaining capital to increase the development of the property now so well known as the Gopeng. After careful study and inquiry he and his friends subscribed the £5,000 required, and thus laid the foundation of a business that has had many and varied beneficent influences in mining circles, both in this country and the Malay Peninsula. The Gopeng has paid handsome dividends for thirty years, and promises a further life of at least fifty years. Other successful enterprises have followed, of which the Tekka, Tekka-Taiping, Rambutan, and Pengkalen are the best known. As for the future, Mr. F. Douglas Osborne succeeds to the chairmanship of the Malayan companies, and he and his partners, Mr. Chappel, Mr. Mair, and Mr. Glenister, will continue to exercise the technical control, while Mr. Wickett's sons will still attend to the financial and the stockbroking sections of the business. The high traditions are safe in their hands.

REVIEW OF MINING

Introductory.—The signing of a preliminary treaty with Sinn Fein has given general satisfaction in commercial circles, for it is felt that with Ireland settled it will be possible for the Government to devote more attention to the many financial problems in this country awaiting solution. Let us hope that the treaty will prove acceptable to all Irishmen, and that the new proposals will be given a fair chance by everybody. In mining circles the most interesting feature of the month is provided by the arrangements for gold prospecting in Nigeria. The metal markets have been more cheerful, and the prospects for the resumption of copper mining in America are distinctly brighter.

Transvaal.—News as to labour conditions on the Rand continues to be of varied character. The Government announcement, to which reference was made last month, did not have as much impression on white labour as was hoped at the time. The unions are now engaged in disputing multifarious points of detail. In particular, there has been a strike at Crown Mines, and the operations were entirely suspended for a time. Cable messages and other news sent to London do not elucidate the position, except that a conference has been called between the Chamber of Mines and the unions with a view to discussing possible economies.

The question of all-sliming, with or without elimination of amalgamation and stamps, continues to present a subject for discussion in this country, where no exact details of the new proposals are obtainable. The latest pronouncement on the subject, received by cable from South Africa, comes from Mr. J. G. Lawn, who mentioned in his speech at the meeting of the Johannesburg Consolidated Investment Company that the New State Areas plant would embody the principle of all-sliming. The new plant will have a capacity of 50,000 tons per month, and it is to be ready early in 1923. Speculation as to the nature of the process is naturally attractive to the average metallurgist, and in this case the question is, first, whether there will be any amalgamation, and, second, whether the cyaniding will be done in vats or by the counter-current system.

The meeting of the Consolidated Gold Fields was the occasion of another attack on the directors by Mr. Aubrey Hyman, a stockbroker with Johannesburg connexions. It is just eight years since he made a similar onslaught. On the present occasion he had omitted to fill the company's requirements as regards qualification for voting or speaking at the meeting, but by the grace of the board and of the shareholders he was permitted to make his speech. Nobody, however, came to his support in moving the resolution he had prepared, so the matter dropped.

Owing to continued losses, production at the Rooiberg tin mines was suspended at the end of September until the tin market recovers. Development is being continued, as also is the sluicing of alluvial deposits.

Rhodesia.—The output of gold during October was returned at 53,424 oz., as compared with 52,436 oz. in September and 47,343 oz. in October, 1920. The outputs of other products of Southern Rhodesia during October were: Silver 13,342 oz., coal 49,306 tons, copper 271 tons, asbestos 629 tons, arsenic 112 tons, and mica 21 tons.

The meeting of the Gaika company, one of the Gold Fields Rhodesian Development group, was occupied in much the same way as that of the Consolidated Gold Fields. Here Mr. Stanley Edwards agitated for a change of control, and the basis of his complaint was the old one about the disadvantages of a controlling company watching the share market as well as managing the mine. There is no denying the fact that a parent company, as a dominant shareholder in a subsidiary, has an advantage in the share market over the other shareholders, and it is therefore easy to fling unpleasant accusations broadcast though not so easy to produce definite evidence. In this case the decisions as to mine policy depend on current development owing to the erratic nature of the ore-bodies, and, moreover, Mr. Cyril Parsons, the consulting engineer, is not a man to write reports to order, so that the present hints are out of place. However, when the voting came, it was found that the shareholders wanted a change in the directorate, so Mr. Edwards was elected in the place of Mr. James Prinsep, the chairman. We understand that Mr. Edwards is now desirous that two other Gold Fields directors shall resign, and that Messrs. R. Rawdon Johnson and H. W. Edney shall join the board.

West Africa.—The reports of Prestea Block A and Abbontiakoon for 1920 were issued early this month. As mentioned some time ago the labour scarcity on the Gold Coast hit the gold mines badly last year. Prestea Block A treated 115,670 tons during the year, yielding gold worth £256,678, of which £61,923 represented premium; against

this were costs of £280,660. At Abbontiakoon 84,805 tons of ore gave gold worth £200,738, of which £17,982 accrued from premium, while the costs were £187,142. The ore-reserve position at Prestea Block A is giving rise to great anxiety. Developments at Abbontiakoon have added considerably to the reserve, but, on the other hand, the lode has not yet been found on the 16th level.

Nigeria. The Bisichi company has issued a statement relating to the exceptionally important developments on one of its properties, which was originally secured for the company by Mr. A. W. Hooke when he was in charge. It will be remembered that about a year ago this company absorbed the properties of its neighbours, which were under the same control, the Forum River, Ninghi, and Northern Nigeria Trust. The rights to the particular property in question were held jointly by the Bisichi and Forum River companies. Since the amalgamation this ground has been systematically tested under the direction of Mr. H. E. Nicholls, of the firm of Lake and Currie. The area is 3¾ square miles in extent, and is flat in the centre, with slightly undulating country beyond. The Forum River and its tributaries wind through the flats. On the northern bank of the present river there is an old river bed more or less parallel, and it is this ground that received first attention. By the end of June the deposit had been proved for a distance of 4,330 ft., averaging 970 ft. wide, to a depth of 21 ft. In all 577 bores and pits were sunk, and it is calculated that the area so tested contains 3,266,740 cu. yd. averaging 3 lb. of cassiterite per yard. Further pitting has since been done, and the results appear equally good, though exact data are not yet available. There remain lengths of ¼ and ½ mile respectively at the two ends still to be prospected, and also the flats on the other side of the river. This discovery is the most important made on the Bauchi Plateau for several years.

Prospecting for lode gold in the belts passing from south-west to north-east through Jebba, Birnin Gwari, and Kano continues to form an important feature of interest, and a number of exclusive prospecting licences have been applied for. On these, working options have been granted to several Nigerian and West Australian companies, among the latter being the Great Boulder Proprietary, whose manager, Mr. Richard Hamilton, has sent over one of his trusty prospectors, Mr. James Shea, to conduct the search on behalf of this company. Of individuals participating financially in the prospecting of this belt, Mr. John Waddington deserves special mention. He and Mr. Hamilton rely on Mr. Shea for a sound judgment as to the practical possibilities of the new gold areas, and there will be no rash promotions as far as they are concerned. It is generally believed that other individuals and companies taking interests in the same district will adopt the same cautious attitude.

The Nigerian Chamber of Mines has been pressing for reductions in charges of various sorts incidental to tin mining. A reduction in smelters' returning charge from £14 to £10 per ton has been secured for next year, and there seems a probability of railway rates being reduced before long.

Australia.—The companies at Broken Hill consider that metal prices have recovered sufficiently to warrant some extension of mining operations. The British Broken Hill is to restart mining, and the North and South mines are to increase their output. At the British mine, recent development at depth has given excellent results, particularly on Nos. 11 and 12 levels.

During the year ended September 30 the Mount Lyell company smelted 45,235 tons of North Lyell ore, 93,107 tons of Mount Lyell ore, and 14,343 tons of concentrate. The yield of blister copper was 5,786 tons, containing 5,738 tons of copper, 178,380 oz. silver, and 4,744 oz. gold. Recent diamond-drilling has indicated the presence of a large amount of additional ore. The profit was £51,830, but owing to present general conditions no dividend is paid. The directors are now applying to the Arbitration Court for a reduction in wages to agree more nearly with the reduced cost of living.

The Electrolytic Zinc Company of Australasia announces that the first unit of the new plant at Risdon, Tasmania, started running on November 22. The horse-power of this unit is 15,000, and the yearly output of zinc is estimated at between 20,000 and 22,000 tons. The second unit, of similar capacity, will be ready in about a year's time. The company will require additional capital to complete the plant.

Owing to the excessive cost of supplies and labour, it is no longer possible to win ore at a profit at the Bullfinch mine, and all operations have been suspended for a time. Options have been secured on territory in the Nigerian gold belt.

Hampton Celebration announces that a mill is to be erected, with a capacity of 100 tons per day. This should be ready to start in April. The proved ore above water level is estimated at 50,000 tons, and out of the profits accruing from its treatment funds are to be applied to sinking the main shaft further and testing the lode in depth.

Papua.—As the results obtained by the joint venture of the British and Australian Governments for exploring for oil in Papua have not been satisfactory, the British Government has withdrawn from the scheme, but the Australian Government intends to continue the investigations.

Burma.—The report of the Burma Corporation for 1920, just published, is not exactly cheerful reading, but in the present circumstances of the world's metal trade this is only to be expected. Particulars of output and reserves are given elsewhere in this issue. Conditions have rendered it necessary to postpone the erection of a new smelter, and to suspend the construction of the zinc works and the development of the Namma coalfield. Thus the company finds it is obliged to continue the policy of smelting ores, and later concentrates, high in lead and silver. The report does not mention the fact that Mr. E. P. Mathewson, the doyen of American metallurgists, is now in Burma, sizing up the position from both the technical and commercial points of view. It is to be hoped that the board will take his advice and give him a free hand. There is one point in the report of Mr. R. G. Hall, who recently completed his service as engineer in charge, that has proved disconcerting to shareholders ; we refer to his remarks about the difficulty in securing suitable labour. This question has not been mentioned in previous reports, but it is fully appreciated by those who know Burma, and has often received attention in the MAGAZINE, particularly in contributions by Dr. A. M. Finlayson and Mr. H. D. Griffiths. As regards the Bawdwin mines, there is no suitable local labour, and the Yunnanese who come to the mines in seasonal ebb and flow cannot be induced to stay in Burma during the rainy season from June to October. The Burma Corporation is now endeavouring to form settlements of members of tribes from the borders of the Shan States and Yunnan. We believe that these tribes, which are neither Shan nor Yunnanese, formed one of the difficulties when the boundary between Burma and China was settled, for each party wanted to hand over the territory to the other owing to the tribes not being amenable to discipline. It is gratifying to find now that these races are showing signs of being desirous of settling down to industrial life.

Elsewhere in this issue we publish an article by Mr. Harry D. Griffiths on the mineral resources of Upper Burma, in which he draws attention once more to the possibilities in connexion with the gold deposits of that country. Upper Burma is a comparatively new country as far as British mining operations are concerned. It was annexed in 1885, and for some time afterwards it was so unsettled as to be unfit for outsiders. In 1892 the Indian Government geologists had decided that King Thebaw's gold mines were not worth acquiring on public behalf. With such a judgment circulated broadcast it was clear that private enterprise would not be able to raise adequate funds for prospecting and exploitation. Consequently the early pioneers, such as Messrs. C. M. P. Wright, A. H. Bromly, and Trafford Wynne, worked under every sort of disadvantage, and had some pretty hard things to say of Government methods. In fact, the last named put it on record at a meeting of the North of England Institute of Mining and Mechanical Engineers in 1896 that the word "absurd" was the only one suitable for describing the mining laws and regulations imposed by the Indian Government. Things have improved lately, as Mr. Griffiths mentions, and there is now more encouragement for mining operations. Means of communication also have been improved, and fevers can be more easily combated. There has never been any doubt as to the great extent of the alluvial and eluvial gold deposits, but nowhere have deposits been found that can be called rich. Mr. Griffiths makes no claim for any such deposit, and looks to bucket-dredging on a large scale as the means for profitable work.

When the Indo-Burma Oilfields, Ltd., was formed last year the intention was to start work on the company's main property in Yenangyaung. Owing to the delays in receiving the plant, the engineers occupied themselves in prospecting the company's properties at Yenanma and Padaukpin, and the results were so satisfactory that well-sinking was commenced at those centres instead of at Yenangyaung. The reports now being received relating to oil-flow are most encouraging. The company has made a rearrangement of its policy. It will confine

its drilling operations to Yenanma and Padaukpin, and has made a deal whereby its Yenangyaung property will be drilled on a co-operative basis by the Yomah Oil Co. The refining is also to be done conjointly with the Yomah, and a company called the United Refineries Burma, Ltd., has been formed to inaugurate and carry on this work at Rangoon. Dr. Murray Stuart, late of the Geological Survey of India, has been appointed geologist to the company. It will be remembered that Dr. Arthur Holmes is geologist and also manager of the Yomah.

The British Burmah Petroleum Company is issuing £600,000 8½% second mortgage debentures for the purpose of financing an augmented development and drilling programme, both at Yenangyaung and at properties in a hitherto undeveloped oil area ; also for the purpose of completing the electric installation in the field and to extend and modify the plant at the refinery.

Malaya.—During the year ended July 31 the output of tin concentrate from the Pahang Corporation's mines was 2,269 tons, extracted from 169,931 tons of ore. In addition, 143 tons was obtained from alluvial ground, making the total 2,412 tons. The tonnage was less than during the previous three years, but the yield per ton higher. The cost continued to increase, and the fall in the price of tin had a serious effect on the income, so that the profit was only £9,260, as compared with £152,279 during the previous year. Development in depth has still been restricted owing to water troubles, but as the new pumps are now on the spot a resumption may be expected shortly. The reserve is estimated at over three years' supply to the mill.

Canada.—As mentioned in a recent issue, Mr. W. H. Goodchild was commissioned to make a geological examination of the Tough-Oakes, Burnside, and Sylvanite properties belonging to the Kirkland Lake Proprietary. He has now returned, and is submitting a report. Both he and Mr. S. C. Thomson, the consulting engineer, consider the present developments most encouraging. There is strong hope that it will be possible to start milling by the end of March.

United States.—The Tomboy company has suffered during the last few years from the worries that are general among gold mines in the United States, namely, increase of cost of labour and supplies without any compensating advantage accruing from a gold premium. The report for the year ended June 30 last shows that during the first part of the year the policy was to work as much of the better grade ore as possible, and to restrict the tonnage ; subsequently the new manager, Mr. N. F. Kelsey, found that the best ore was rapidly diminishing, so he adopted the policy of working a maximum amount of average ore. The total ore milled was 197,557 tons, an increase of 51,491 tons as compared with the previous year. The yield of gold as bullion and in concentrates was worth £223,694, and the working profit was £18,006. After allowances for depreciation and taxes the year ended with an adverse balance of £2,681. During the last year or two development has necessarily been restricted, owing to lack of suitable labour, and in addition many of the workings fell into disrepair. Development of the Virginius vein, which contains ore of a better class, is now being pushed, and it is hoped this source of ore will be available shortly.

Mexico.—The directors of the El Oro company report that conditions in Mexico have improved recently, and that, in consequence, the costs have been reduced \$1·00 per ton. Thus it has been possible to work ore of lower grade. During the year to June 30 last, gold worth \$2,545,446 was extracted from 383,043 tons of ore, resulting in a profit of \$357,010, or £95,202. Railway profits were £54,273, and interest and dividends brought £31,124. The company is saddled with big taxation, having to pay \$333,297 in Mexico and £56,800 here. The shareholders received £57,375, being at the rate of 5%. Owing to poor results and the great heat, development has been abandoned on the 2,200 ft. level on the San Rafael vein. The reserve is estimated at 282,124 tons, averaging \$7·96 in gold and 2·11 oz. silver.

China. — The Chinese Engineering & Mining Company reports that the net profits of the Kailan Mining Administration (the company that controls the marketing of the coal produced by this company and the Lanchow company) for the year ended June 30 were \$7,313,448, of which the company's share was \$3,850,012, equivalent to £527,371. Out of the profit £261,220 was allocated to British taxation accounts, and £308,000 was distributed as dividend, being at the rate of 22% tax paid. The sales of coal by the Kailan Administration during the year were 3,775,379 tons. Investigations are still proceeding with regard to the establishment of an iron works at Chinwang-tao.

MINING POSSIBILITIES IN BURMA

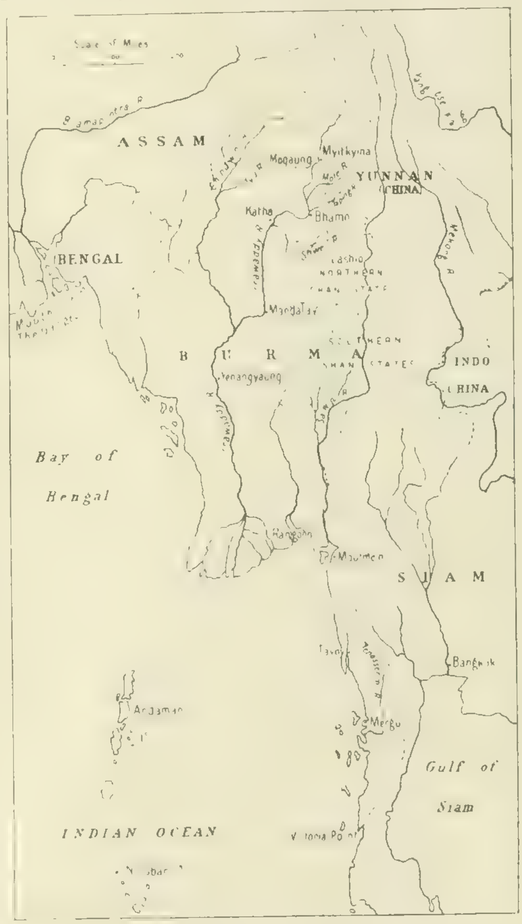
By HARRY D. GRIFFITHS, A.R.S.M., M.Inst.M.M., M.Inst.C.E.

The Author shows that the mineral resources of Burma are not fully appreciated by the general public, and presents evidence that there are many opportunities for profitable ventures, particularly in connexion with gold-dredging.

INTRODUCTION.—Burma attained some fame as a mineral-producing country during the Great War, when the production of wolfram under pressure from the Government of the Province was brought up to a high figure. Many of the mercantile firms in Rangoon, which previously had not been particularly interested in mining operations, were urged to devote some of their capital to the mining of wolfram. The industry was controlled by the Government, which bought the tungsten ore at a price of 57s. 6d. per unit, and made also an allowance to cover the fluctuating price of the rupee. Many properties in the district of Tavoy, Lower Burma, were equipped and manned by the best available labour, and by the beginning of 1918 the production of that district was at the rate of over 6,000 tons per annum, practically equal to the pre-war production of the world.

In most instances the ore was obtained from surface quarrying of the veins, and very little underground work was done. Advance development was totally neglected, and the mines had only a hand-to-mouth existence. The cost of labour and material having largely gone up during the war, the mining enterprises at the best just paid their way, and it is very doubtful if the commercial firms engaged made a 10% profit on their outlay.

The price guaranteed by the Government was to continue until twelve months after the end of the war, and on the strength of this several of the regular mining companies enlarged their equipment and staff so as to place themselves on a footing appropriate to their resources. Less than six months after the Armistice, the Government withdrew their guarantee and offered a compensation commensurate with what each mine should have produced during the full period. The compensation was liberal in the case of individual mines or miners that had no outlay in machinery and plant, but proved totally inadequate for those serious enterprises that had spent large sums of money in equipping themselves in a proper workmanlike fashion. The demand for wolfram rapidly decreased and the price quoted for tungsten ore very quickly became nominal. By the end of 1919 it is reckoned that the Government had on hand some 6,000 to 10,000 tons of wolfram, which presumably it proceeded to sell. The quotation promptly dropped to about 12s. 6d. The result, as far as Burma was concerned, was a practical stoppage of the industry.



MAP OF BURMA.

That a partial stoppage was to eventuate sooner or later, even with a fair price for the metal, was foretold by the writer, who pointed out that surface scratching of

lodes could not last long when no development in depth had been undertaken. Had the local Government insisted upon a percentage of the profit obtained by the small owners being devoted to underground development, a potential industry would have been established; and would have been in a position to restart as soon as prices had again become reasonable. As it is, however, with the exception of a few of the serious enterprises already mentioned, the wolfram industry of Burma will not be of any importance in the future unless a large amount of capital be put into development and plant.

The few companies which are still holding on manage to do so on account of the tin ore which exists in connexion with their wolfram deposits. The largest producing mine yields ore containing half tin and half wolfram, and the next one in importance is now working the foot of a detrital talus, which produces practically clean tin ore.

The production of tin in Burma has never been an important one, as for many years the only tin ore exported was that which occurred with the wolfram, and from which it was separated. During the early part of 1920 the abnormal price prevailing for tin induced a search for tin ore, and led to many discoveries being made, which will be referred to later.

As regards other base metals, Burma has proved itself of some importance. The company operating the Bawdwin mines has spent a lot of capital in opening out and equipping the well-known deposit of zinc-lead-silver ore. The development continues in a most satisfactory manner, and there is no doubt that on completion of their new smelter a handsome profit will be obtained. Gold mining has also been tried in the past, but owing to a concatenation of adverse circumstances has not been profitable and came to a stop.

The present position of Burma as far as metal mining is concerned, is therefore that it is undoubtedly a metal-bearing country, but that it has not yet given any profit on the capital invested in mining. This fact has led a good many engineers, after a short sojourn in the country, or the examination of some particular spot, to state that Burma is not a mining country.

The writer has now been in continuous and intimate touch with Burma for the last eight years, and has probably done more individual prospecting, testing, and development than any other engineer, and he has come to the conclusion that there are many mining propositions capable of being worked profitably. These will be described later.

Some of the main drawbacks to mining have been the difficulties of communications, and the reluctance of the Government of India to allow any adequate expenditure on roads and tracks to mining districts. It is a pleasure to state, however, that the local Government seems disposed now to help the development of the country by every possible means. A new post of Development Commissioner has been created, and already it has shown its anxiety to be of all possible help to the industries of the country. Questions relating to mining are now considered by the Development Commissioner, instead of going through the routine of several other departments, whose decisions, owing to want of intimate knowledge, were slow and mostly unfavourable to the miner. Mining matters are promptly attended to by the Development Commissioner, whose department is provided with special powers and funds to be devoted to any urgent work. It generally took from two to three years for an application for a mining lease to be signed and delivered. Now it can be all fixed up inside of six months.

Causes that have retarded Mining Development.—Before considering a mining country it is essential to carefully consider the reasons why the pioneer mining companies have failed to make good. Unfortunately this is not often done, and the layman, judging by past results only, is prompt and emphatic in his condemnation. Burma has had to struggle through all the same difficulties as other mining countries have had to contend with, and is still under a cloud. There is not any doubt whatever that with a little more confidence in the industry and its present leaders, Burma will emerge from the cloud, and will become an important factor in Imperial production.

The foremost industry of the country, that is, the petroleum industry, has been the only one so far that has gone prosperously from the start. Its success has undoubtedly diverted a lot of capital which otherwise might have found its way into prospecting mining ventures. That industry is still making vast strides. Systematic search is conducted continuously, and new discoveries of oilfields are being made. Virgin oil ground, in the writer's opinion, exists west of Mandalay and the Irrawaddy, also in the Upper Chindwin, and recently a discovery

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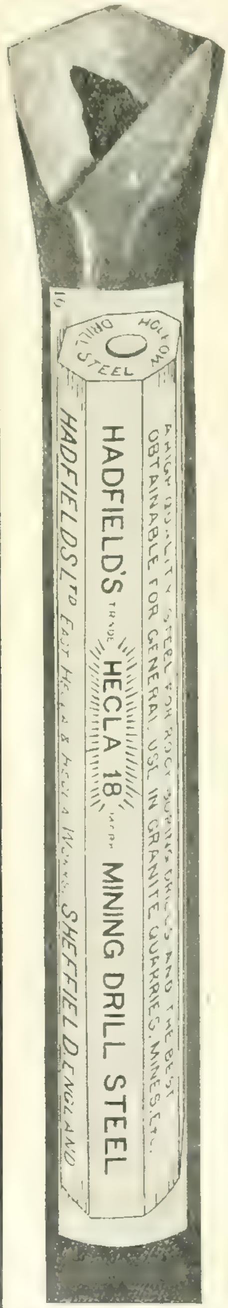

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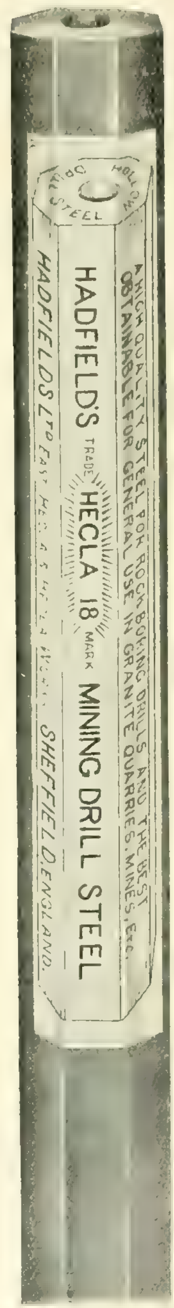

of oil-shales, reputed to be higher in oil contents than the Scottish shales, has been made in the Moulmein district. The Akayab district, also, has not yet said its last word. If, therefore, the oil industry could legitimately be classed as a mining industry, Burma would indeed be reckoned as a foremost mining country.

The jadeite mining industry is unique to Burma, but owing to the condition under which exploitation is allowed, there is no room for any investment or commercial expansion in that line, and the Government derives little from this source. The ruby industry has been carried on for many years past, but of late, owing to conditions created by the war, it has not been remunerative. The gem-bearing ground is very far from being exhausted, and, in fact, new ground is constantly being opened out, and there can be little doubt that the industry will soon again become a profitable one. In the base-metal line, one of the most important deposits in the world of zinc-lead-silver ore has been, as already mentioned, opened out in a very extensive way at the Bawdwin mine. Lead and silver only are being extracted at the present time at a very substantial profit, and as soon as the new smelter is completed the production will be on a very large scale, and the shareholders will receive handsome dividends on their investment. Had it not been for the unavoidable delays due to the war, to the subsequent dislocations of home industries, and lack of Government assistance in the way of providing means of communication, that result would have been achieved by this time.

The wolfram mining industry has had to contend with many difficulties in the shape of patchiness of the lodes, pinching or impoverishment in depth, inefficient labour and management, want of necessary machinery, etc., and can be said to have been remunerative only during the period of the war. The best and most durable mines have been exploited by means of English capital, but the bulk of the war production has been produced by individuals or small local concerns working small reefs and patches at the surface. On resumption of mining when the rise in the price of wolfram has taken place, those properties only which have been scientifically equipped and managed will be successful.

Tin-mining has become a regular industry only since the end of the war, and the practical cessation of wolfram mining. Most of the tin now produced is obtained from alluvial ground and eluvials. Tin-dredging has been carried on very successfully for many years in the Tavoy district by two enterprising miners. Some two years ago this enterprise was acquired by one of the leading mining companies in Rangoon, who at once proceeded to erect a large and up-to-date bucket-dredge. This dredge commenced operations this year when the price of tin was favourable, and gave magnificent returns, which should have enabled the company to distribute immediate dividends. Unfortunately the price of tin suddenly dropped down to an undreamed of figure, and has since continued at that low level, so that although the returns even now more than cover the costs, dividends are not likely to be forthcoming until the price of tin reaches at least £175. Had it not been for this misfortune the tin-dredging industry would by now have firmly established itself as a remunerative one. This desideratum is, however, only postponed, and is sure of achievement.

One other large company which was working wolfram had to cease that class of work when there was no market for wolfram. Fortunately, however, a tin deposit has been discovered at the foot of the huge talus which provided most of the wolfram, and all the hydraulicking plant was turned on to it. The tin production soon become an important one, and at the price then prevailing for tin a handsome profit was in view. The sudden drop in the price since the beginning of this year has, however, destroyed the hope of dividends, and the mine can now no more than pay its way.

Two other large companies working on wolfram-tin ores have had lately to cease operations for the same reasons, although they had been dividend-paying concerns previous to that.

Some years ago attention was paid to gold mining, and four dredges were put to work in the upper reaches of the Irrawaddy. This work was carried on with variable fortune. The operations were confined to the actual river-bed, and apparently little was thought of the gold wash in the bank. The work of the dredges was very irregular owing to machinery troubles, and to time being wasted in working round the river bars to look for intervening pockets; and although at times one dredge could return

1,000 oz. per month, the operations as a whole were unprofitable and came to an end. The reasons ascribed for this failure appear to be many, among which were suspected gold thieving, expensive management, overstaffing, and poor knowledge of gold deposits. The failure of this concern put a complete stop to all gold-prospecting operations in Burma, and created a strong adverse feeling towards gold mining.

At about the same time another property, which had been inspected and reported upon favourably by two well-known and trustworthy engineers, was floated, and a dredge was ordered. The dredge was duly received in Rangoon and then forwarded on to the spot. The only way to reach the property, however, was by going up a small and shallow river some 120 miles. This journey could only be accomplished during the rainy season, when the river became practically a swift rushing torrent. The machinery placed in shallow-draft country boats began its journey, and a succession of accidents deposited it all at the bottom of the river. No part of this machinery, it is believed, ever reached the property, and another disappointment was thus added to the experience of the gold-mining investor.

One gold-quartz proposition was capitalized, equipped, and started. The returns were sufficient to enable paying back a debenture issue, and dividends to the shareholders, when suddenly the management reported that the reef had "dropped down" too deep to be exploited successfully, and the concern was wound up before the investor had had his investment returned in full. Thus was one more nail added to the coffin of gold mining, but it is only fair to say that the pioneers of this venture worked under very disadvantageous conditions and discouragements.

Recently a well-known engineer, representing the biggest gold-mining firm in India, visited this mine, and it is whispered that after having put in a short cross-cut he struck the faulted reef and obtained high values. In any case the fact is that active development has since been carried on at that mine, and that considerable extension of development is being considered.

Several other occurrences of gold have been reported, but owing to there being no adequate means of communication, and a lack of confidence, the schemes for exploitation came to nothing.

Taken as a whole, therefore, but with the exceptions mentioned, mining in Burma has not been tackled properly and seriously.

MINERALS IN BURMA.—That Burma is destined to become a mining country is shown by the following list of metals and minerals that are now being exploited, or whose existence has been definitely ascertained :—

(1) Now being exploited (mineral oil excepted) : Wolfram, tin, lead, copper, zinc, silver, gold (by natives), jadeite, rubies, and zircons.

(2) Ascertained or in course of development : Gold, platinum, bismuth, antimony, graphite, oil-shales, coal, etc.

The writer has explored many parts of Burma, and his observations have led him to the conclusion that, outside of present exploitations, great possibilities exist (in order of importance) in gold, platinum, and tin.

The list may not be a very large one when compared to some other countries, but it makes up in containing those particular metals for which there is at present, or soon will be, a great demand.

GOLD.—All the early explorers are unanimous in mentioning the occurrence of gold in many parts of Burma, and at the present time there are many thousands of natives working gold in many directions. The production from this source does not appear in the Government's official returns, for the good reason that it is not declared, and finds its way out of the country or to the local bazaars without any benefit to the Government. It will, however, astonish many to see what the official gold production has been during the last few years, in spite of the fact that only at the most two properly constituted companies were at work. The production has been as follows :—

Year.	Ounces.	Estimated Value in Rupees.	Value per ounce in Rupees and Annas.	
1905	621	36,278	58	6
1906	2,301	1,32,830	57	11
1907	3,837	2,23,844	58	5
1908	6,950	4,59,060	66	—
1909	8,488	4,91,972	58	—
1910	5,996	3,45,740	57	8
1911	6,421	3,65,662	56	14
1912	5,068	2,90,058	57	3
1913	5,393	3,11,501	57	12
1914	3,704	2,14,425	57	14
1915	3,182	1,85,025	58	2
1916	1,892	1,15,638	61	2
1917	1,078	63,718	59	14
1918	171	11,089	66	14
1919	38	3,421	90	—
Totals and Averages	55,140	32,50,261	58	14 = £4.

The gold occurrences of Burma can be classed into three groups: The Upper Chindwin, the Bhamo district, and the River districts.

Upper Chindwin.—In this district the older rocks are covered by an enormous area of a loose conglomerate which carries gold. The denudation flow has apparently been from north-east to south-west to the Uyu Chaung (a tributary of the Chindwin River), which can be considered as the southern limit. The conglomerate comprises enclosures in the shape of well-rounded boulders of all the older rocks to be found in the vicinity, including boulders of jadeite, as well as granites, quartzites, and other rocks, which so far have not been found in that part of the country. In some instances this detrital deposit attains an enormous thickness, and in a portion of the right bank of the Uyu can be seen rising perpendicularly for 300 ft. from the river's edge. The boulders are generally cemented by fine grit and sand, with little clay, but in places iron infiltrations have taken place, and have transformed the conglomerate into a hard one.

Subsequent denudation has bared the underlying country rock in places, and has caused a concentration of the gold all along the Uyu Chaung and its tributaries on the right bank. Every creek on this bank is prolific in gold, and many hundreds of Cochins exploit it after each rainy season. In some of these two natives, fossicking among the boulders produced, at the time of the writer's visit, from ½ to 1 oz. per day. In these small valleys and creeks the writer found gold in all parts of the conglomerate, and many cross-sections tested gave an average of 3 to 6 grains per yard.

The particular feature of the gold is that it is almost invariably associated with platinum. The average sample taken by the writer yielded 75% gold and 25% platinum, which could easily be separated. The fineness of the gold is between 825 and 900. The washing of the conglomerate bulk samples was done in a very rough sluice-box, cut out solid from a small tree, and, of course, the fine gold was not recovered.

Along the course of the Uyu River there are many bars running across, above and below which coarse gold and platinum are found. An attempt has been made to exploit these, either by diverting the river, or by means of divers, but owing to the presence of large boulders the operations, as was to be expected, were not successful. There are also many "flats" along this river in which the conglomerate is exposed, and which, given a sufficient area, would render dredging operations possible. In many parts, the conglomerate could be exploited by hydraulicking, but the difficulty lies in the want of storage places for water. Near the river itself water could always be obtained by pumping, but this method would probably not prove remunerative. The writer has only explored a small portion of the area, but has seen sufficient to convince him that further systematic exploration will reveal many portions worth exploiting. The boulders of jadeite in the conglomerate occur mostly to the south of Tamaw, where the celebrated jadeite has been exploited for many years. They are not very numerous, but make up by their being of large size, and containing the dark green variety of jadeite so much prized by the Chinese, and which is now unobtainable in the Tamaw mines, and realizes a high figure. In this particular portion of the gold conglomerate, it has been reckoned that the realization of the jadeite boulders would cover the costs of hydraulicking, leaving the gold as profit.

In contemplating exploitation of the Upper Chindwin conglomerate some serious drawbacks will have to be reckoned with and overcome. During the monsoon season communication with either Mogaung or Myitkyina is almost impossible, owing to lack of roads, bridges, etc., and at other times the whole of the traffic is done by mule transport. A remedy to this state of affairs is not impossible, but it would necessitate assistance on the part of the Government. Fever is bad in the district, and the whole native population for that reason, and also because no work is possible during the rains, migrates *en bloc* to higher ground, to return when the sun again shines. The local inhabitants do little cultivation, and confine their efforts almost exclusively to working the jadeite deposits, which absolutely belong to their chiefs, who only pay a small royalty to the Government. They would not do for steady employment, but Yunnanese coolies, who are physically a fine race, with greater powers of endurance than the local natives, could be obtained in any number from across the eastern border. These Yunnanese have the monopoly of mule transport in that part of Burma, and stream across the border with their

hundreds of ponies when the rains cease. The local natives are peaceful enough, as long as there is no interference in what they consider their rights, and it is certain in the case of some properties on the Uyu River, where they now exploit the gold in the creeks, that some amicable arrangement would have to be brought about before starting work on a large scale.

These drawbacks are, after all, no greater than miners have encountered in other countries, and with a little perseverance and

Fig. 1.—Gold Wash in Terrace above River Level.

tact can be overcome, but so far they have been sufficient to retard enterprise.

In addition to the syndicate which was formed to exploit the Uyu river bed, only one other local syndicate has made an effort at exploitation. The failure of the latter was not due to the poorness of the gold wash, but to the difficulty of impounding water for hydraulicking in quantity sufficient to last over the dry season, and want of cash to hold on until the next rains arrived. In these two cases, again, local want of confidence in gold-mining seriously interfered with the securing of valuable data.

It is hoped that the detailed Geological Survey, which is extending in that direction, will give valuable indications as to likely gold deposits, as it did in the case of wolfram and tin in Lower Burma.

Bhamo District.—The district is very easily accessible and possesses rough tracts running parallel to the Irrawaddy and skirting the foot of the hills that rise from the Irrawaddy basin to China, and several of the tributaries of the Irrawaddy can be utilized for transport of machinery. Several tracks also radiate from Bhamo to China (Yunnan) across the hills, and during the dry season a large amount of traffic to and from China, by pony transport, takes place. The hills form the eastern edge of the Irrawaddy basin, which at one time, between the first and the second defile, was probably a huge lake, the western shore being represented by the range of hills running south from Myitkyina. Several rivers whose source is in the high country of Yunnan have cut their way through the ranges, flowing in a westerly direction, and cutting through the flats until they reached the Irrawaddy. A large flow of denudation has taken place from east to west, and has resulted in the deposition of a detrital gold wash all over the western flank of the hills, over a distance of many miles, say, from Mandalay to Myitkyina. This wash has filled in the inequalities of the slopes until the rivers and streams flowing west have cut through. The principal of these rivers are from south to north, the Shweli, which merges into the Irrawaddy south of Katha, the Taping River, 24 miles north of Bhamo, the Mole River, 30 miles further north, and the Namsang River, a further 12 miles. The original denudation brought the detrital matter right into the Irrawaddy lake, where with the assistance of the subsequent streams it became a typical alluvial deposit, filling up the lake and producing the present flats. This alluvial has been spread right across the basin to the hills west of the Irrawaddy. For many years past the terraces of the original detrital wash have been exploited on the flank of the hills by natives. The flanks are dotted by innumerable pits and quarries, but in the flats, owing to their being waterlogged, no work has been done. The gold wash in the flats is undoubtedly a re-sorted deposit, from which have been eliminated certain enclosures of friable and easily decomposed rocks, which are found in the original deposit in a very decomposed state, thus leaving water-worn enclosures such as quartzites, hard schists, and quartz.

A difference in the appearance of the two kinds of wash will be evident from the accompanying photographs. Nos. 1 and 2 show quarries in the terraces high above water-level, and No. 3 the re-sorted wash on the river bank.

The writer has put in more than two years of exploration of these deposits, and is still wondering why such enormous wealth has so long remained undeveloped. The detrital terraces are richer than the re-sorted wash in the flats, and where tested by extensive sluicing have yielded a value of 8 to 11 grains per cubic yard. A large number of bores in the flats have given an average of 6 to 8 grains per cubic yard, and have proved conclusively that from the foot of the hills the bed-rock slopes at a very slight angle so that at a distance of 2½ miles it lies at a depth of only 60 ft. This helps to support the contention that the flats were at one time represented by a shallow lake, and that there is an untold quantity of ground to be worked at very reasonable depth.

The feature of the re-sorted wash is that at all points it carries gold from its very top, and the increase of contents with depth is very rapid.

The three most important properties in this district have been taken up and thoroughly tested by an enterprising local syndicate, called the Tavoy Tin Syndicate, which had been formed originally to look for alluvial tin deposits in the Tavoy district. The syndicate's work in this line will be detailed further on. The three gold properties have been selected at those points where the Taping, Mole, and Namsang Rivers emerge from the hills on to the flats, and where naturally the greatest amount of concentration of the re-sorted deposit has taken place, and the prospecting has fully confirmed the deductions of the syndicate's engineer. All these properties contain terraces of the original wash, as well as a large extent of the re-sorted wash. For instance, the Mole property contains over 150 million cubic yards of 6 grain wash, the Taping property 30 million cubic yards of old terraces of a value of, say, 8 grains (some spots yielded 1 dwt. 12 gr.) and 2,000 acres of dredging wash, and the Namsang property has some 3,000 acres of wash. These three properties are the only ones which have been taken up so far, and they show as mere dots on the map of the area that is covered by gold wash.

FIG. 2. GOLD WASH IN TERRACE 30 FT. ABOVE RIVER LEVEL.

The local prejudice against gold is still

so strong that in all probability the capital needed for the exploitation of these properties will have to be secured abroad. Tempting offers from America have been received for the purchase of these properties, but, unfortunately, the Burma laws do not allow any foreigner to hold more than a 40% interest in a mining property, and, of course, American money could only be put up on the condition of American control.

It is quite certain that had such an extensive field been found anywhere in or near the United States dozens of powerful dredges would have been at work long ago. The bucket-dredging conditions throughout the district are ideal, good even soft (decomposed schists) bottom, no clay, no large boulders, no sunken logs, water for paddocks always abundant. The terrace and re-sorted wash is quite loosely cemented, and in no place so far has any laterite been found. The gold is generally fine, but easily concentrated, and has a fineness of 900 to 925. An occasional trace only of platinum has been spotted, but galena very rich in silver, native silver, etc., are found in the concentrate.

The writer has explored the hills right up to the China border, but has failed to locate any veins, the denudation of which might account for the presence of the gold in the wash. In fact, the boulder enclosures of the wash are mostly of rocks, which only occur a long way east in the high mountains of Yunnan. The failure of proving the existence of gold reefs is of no consequence when one considers the huge amount of detrital gold which is begging to be extracted. The writer is confident that in time the Bhamo district will become an enormous goldfield.

The Shweli river joins the Irrawaddy through a series of hills, below the great Irrawaddy basin. It does not emerge into extensive flats like the properties described, but along its course it has many basins or flats, filled in with wash of high value. The successful exploitation of these is dependent upon their extent and contents, and also on their accessibility. At the present time access to these flats is difficult, and often several ranges of hills have to be traversed to reach them, but there is no doubt that in the future the present difficulties will be surmounted.

THE RIVER DISTRICTS.—These may be said to comprise the river and immediately adjoining flats of the Irrawaddy from, say, 100 miles north-east of Myitkyina to the second defile south of Bhamo, and the whole of the course of the Salwin River with all its tributaries inside the borders of Burma.

As already described, a serious attempt, ending in failure, has in the past been made to exploit the Irrawaddy bed in the vicinity of Myitkyina. The probable reasons of the failure have been described, and it has struck the writer that the work has been too much localized in a southerly direction from Myitkyina, where both banks of the river are rocky and eventually rise to form the first defile, and that sufficient attention has not been paid to the flatter portions to the north, where the banks of the river show a re-sorted wash similar to that of the Bhamo district. A broad view of exploitation does not seem to have been considered, and the greatest effort was directed to the cleaning out of the rich pockets in the actual bed of the river.

Wash is also obtained south of the first defile mentioned, and is undoubtedly the western continuation of that obtained in the eastern portion of the basin. This wash, being in some instances 15 miles away from the point where it began to be re-sorted, may not prove as high in value as at, say, the Mole River, but there is no evidence to show that it is of unprofitable value. The fact that at Mole River the wash at a distance of 2½ miles from the foot of the hills does not show any appreciable decrease in value, as compared to the nearer ground, would give hopes that even much further away it would probably still be rich enough to justify exploitation. The flats above the defile have a better chance as they are very much nearer to the foot of the hills, over which the wash has poured west.

In places, owing to the inequalities of the old lake bottom, the wash will be found to extend beyond practical dredging depths, but it is thought that the majority of it will be obtained within 50 to 70 ft.

Below the second defile, and for some considerable distance to the south, gold wash is occasionally seen in the bank of the Irrawaddy, especially in the vicinity of the confluence of the Shweli river.

On looking at a map of the country, it is at once seen that the name of many of the villages, streams, hills, etc., begin with the prefix "Shwe", which in Burmese means gold or golden, and this goes to show that for many generations the presence of gold has been ascertained.

FIG. 3.—GOLD WASH IN RIVER BANKS

FIG. 4.—TWO-FOOT SLUICE-BOX USED IN BULK SAMPLING.

FIG 5.—DREDGING FLATS OF BHAMO DISTRICT.

All the early explorers who attempted to penetrate China by following the course of the Salwin River have reported large native gold workings all along its banks. Later exploration has shown that gold is still being worked on many of the tributaries, either just above water-level in the low ground or up the hills at a considerable height above.

Unfortunately the river Salwin is very difficult to navigate, owing to its many rapids, etc., and its access from the Burmese side is a very difficult one, owing to the rough nature of the country which has to be traversed. Some of the smaller rivers west of the Salwin and running parallel to it have been proved to contain gold. In fact, one or two properties have actually been tested by boring and quarrying, and have shown the re-sorted wash to be of about the same value as that in the Bhamo district. As far as can be ascertained, there are only a very few places where intense reconcentration in certain creeks has made the gold contents sufficient to repay individual diggers, and most of the deposits will only prove remunerative on being worked on a large scale by up-to-date methods.

The occurrences thus described are sufficient, it is thought, to dispel all doubts as to the presence of gold in remunerative quantities in Burma.

TIN.—A systematic search for tin can only be said to date from the end of 1919. Previous to that year very little work was done on tin deposits and the Burma output was practically all obtained from the separation of the tin ore occurring with the wolfram. Dr. J. Coggin Brown, whose name is very familiar to the readers of these columns, happened at that time, and since early during the war, to be mining adviser and chief inspector of mines to the Government, and in that capacity examined geologically the whole of Lower Burma. He particularly pointed out such places in the Tavoy district where alluvial tin might be looked for, but did not get very much response from prospectors. At that time the Tavoy Tin Syndicate had begun its existence, and was prospecting or securing such properties as would be likely to prove tin-dredging propositions. Prospecting was done on eight different properties. In every instance tin wash was obtained. With the exception of one or two properties, however, the tin ore proved to be unevenly scattered, and the wash in quantities too small to justify exploitation. The one exception proved to be a flat in the Pauktaing River, below the point where a suction-cutter dredge had worked successfully for several years. Hundreds of bore-holes proved the value of the ground to be $\frac{3}{4}$ lb. per cubic yard of 70% cassiterite. As far as the writer has been able to ascertain, not many dredging properties will be found in the Tavoy district, but there are many detrital deposits containing tin which will be exploitable by hydraulicking methods.

The tin resources of Burma are found principally south of the Tavoy district, in the Mergui district. Here the topographical conditions are somewhat different. The detailed geology is also different, and more akin to that encountered in the Federated Malay States. Limestone, pegmatites, and phyllites make their appearance, but granite intrusions are few. In many parts of the district these older rocks are covered over by Tertiary deposits. In the hilly ground north of the Tenasserim river, wolfram lodes have been worked, and all the streams flowing to the river to the south, or to the sea to the west, contain patches of tin wash. Many of these are exploited by individual miners, and are made to pay for themselves, but it is doubtful whether there are any patches large enough to justify bucket or suction dredging. South of the Tenasserim, the Mergui series appear to contain more quartzites and phyllites. These are generally largely impregnated with tin, in the shape of well-defined crystals along all the bedding- and cross-planes, forming in places a regular stockwork. This cassiterite is of great purity and very black. In parts of the district, the denudation of these quartzites, sandstones, and phyllites has resulted in some important alluvial deposits, and extensive talus on all the western slopes of the ranges. Another prolific source of tin in the district is the presence of large masses and intrusions of pegmatites. At the surface these are highly decomposed and can easily be washed down, but in depth they become so hard as to necessitate blasting. Near the surface these pegmatites yield from 1 to 3 lb. per cubic yard, and in depth, where tested, the maximum value has been 5 lb. The denudation of these has filled in many depressions in the valleys with a wash carrying tin in profitable quantities. Many of these filled-up basins are worth exploiting by dredging methods. Going further to the south, there are numerous flats, valleys, etc., both on the mainland and in the islands,

containing tin wash, and this continues to Victoria Point, the southern boundary of Burma, just beyond which the Renong Company, the Siamese Tin Syndicate, etc., are being operated so successfully. It can, therefore, be said that the whole of the country south of the Tenasserim to the border is tin bearing.

The means of communication overland are *nil*, and the country is gradually being penetrated from the sea border.

One of the most important discoveries of tin in the district is the Thabawleik mines, which lies some 70 miles from the sea-coast, and is reached by navigating up the Tenasserim and Little Tenasserim rivers. Here an enormous valley is filled in with typical alluvial tin wash, of a depth of 15 to 25 ft. The deposit is very even and has been actually shown to exist over many hundreds of acres. A large number of bore-holes have given an average of 1·4 lb. of 75% cassiterite per cubic yard. The whole of this deposit lies on Tertiary and Devonian rocks lying horizontally, and which contain important seams of coal. One of these being opened up by the Thabawleik mines for their own use is of excellent quality, and much superior to the Rawang coal, which is so extensively used by the dredging companies in the Federated Malay States. It is supposed to be of Devonian age, and on analysis by a specialist gave the following results :—

	%
Moisture	5·30
Volatile hydrocarbons	32·15
Fixed Carbon	47·50
Ash	15·05
	100·00

Calorific Value 12,214 B.T.U.

The coal gives 62·55% of good hard cake carrying 2·33% of sulphur.

Above this property a huge talus at the foot of the hills carries cassiterite in large quantities up to 15 lb. per cubic yard, and the slopes of the hills show stockworks in sandstones capable of exploitation by hydraulicking.

The writer is convinced that this part of the Mergui district, down to the south boundary, is destined to become in the near future a very important tin-field. Its development is necessarily slow, owing to the difficulties of access and the limited amount of local cash available for exploration, but it is satisfactory to note that a certain amount of exploration is already taking place, which is financed from abroad, and success will inevitably be achieved in the near future. The Mergui district is destined to help the Empire maintain its preponderance in the world's tin production, in spite of many difficulties which may be encountered. The only thing needed is fresh capital, which a small country like this cannot itself furnish, and which it must try and secure abroad.

The conditions of tenure of mining ground in Burma are not at all onerous, the titles are unchallengeable, and the Government royalties are very much less than in any other country. For instance, gold is subject to a royalty of 2½% *ad valorem*, tin and wolfram to 30 rupees per ton. Ground rent and quit-rents are also charged for, but for any producing property, in which the amount of royalty exceeds the total of the rent, only the royalty is payable, and vice versa. The royalty on coal is 6 annas per ton, and only 2 annas for coal used on the property itself.

Coal.—So far this has never attained a place in the products of Burma. Inland the industries are dependent upon a very large and cheap supply of wood, and on the sea-border a good deal of coal imported mostly from India is used.

Huge deposits of mostly Tertiary coals have now been ascertained, and some of them are now being opened out, in such districts as are handy to meet local demand. The coal everywhere appears of very serviceable appearance, and similar to that described above. Owing, however, to its light specific gravity and low calorific value, it cannot be expected to compete against Indian coal for bunkering. It will, however, serve for coke making, use in smelters, on railways, river boats, and in all the numerous rice, oil, timber, and cotton mills of the country.

Conclusion.—The subject of Burma's mining future has of necessity been dealt with very briefly in the above notes, but it is hoped that it may draw the attention of our leaders of industry to a bright prospect. British mining enterprise has never been one afraid of difficulties, and the few drawbacks of Burma will be considered as very small compared to others which have been successfully surmounted. A handsome reward awaits the enterprising miner and investor.

VENTILATION AND WORKING EFFICIENCY

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The author discusses the modern principles of ventilation and working conditions as applied to deep and hot mines.

(*Concluded from November issue, page 286.*)

THE USE OF THE KATA-THERMOMETER. To use the instrument for measuring purposes the bulb is heated in warm water at about 80° C. (this can be carried about in a Thermos flask) until the spirit (coloured red) rises into the top reservoir. The column must be free from bubbles, and care must be taken not to let the top reservoir fill, otherwise the instrument may burst. The instrument is then allowed to cool, and the time in seconds taken in cooling from the 100° mark to the 95° mark is noted with a stop watch. The first reading should be neglected so as to allow the glass time to get into equilibrium. The mean of three or five readings may then be taken as desired. This mean time (T) divided into the factor (K) of the particular instrument gives the cooling power (H) directly in millicalories per square cm. of cooling surface per second. One millicalorie per square cm. per second is equal to 0·4 milli B.T.U. (thousandths of a British Thermal Unit) per square foot per second. Each instrument is carefully calibrated by the makers and the factor (K) engraved on the back of the stem. This factor is determined by observing the dry kata cooling power in still air at a standard temperature, t. When the temperatures are expressed in degrees Centigrade, and 36·5 is the mean temperature of the kata during the observation time T, the factor is given by the empirical formula $K = 0{\cdot}27\,(36{\cdot}5 - t)\,T$. But we also have by definition $K = H_d\,T$, where H_d is the dry cooling power. If the difference between this mean temperature and the temperature of the working place be expressed by θ, we get the dry kata cooling power H in millicalories per square cm. per second represented by the formula $H_d = 0{\cdot}27\theta$, where the air is still, but when it is moving Dr. Leonard Hill found by experiment that $H_d = (0{\cdot}27\,t + 0{\cdot}49\,V^{0\cdot5})\,\theta$, where V is the velocity of the air current in metres per second (1 metre per second = 2·24 miles per hour). Hence if θ is known the velocity of the air current can be determined by taking the dry kata reading. This method, as has been already mentioned, is useful for measuring very low velocities, but breaks down with an alternating or badly eddying current. With low continuous currents an accuracy of 10% may be expected, as compared with only 80%–100% with an anemometer. The only method, then, is to supply heat at a known rate to the air current electrically; or to use a hot-wire anemometer. Further experiments gave the equation :—

$$H_w = H_d\,(0{\cdot}27 + 0{\cdot}49\,V^{0\cdot5}) + (0{\cdot}08 + 0{\cdot}10\,V^{0\cdot3})\,(F - f)^{\frac{4}{3}}.$$

where H_w is the wet kata cooling power, F = vapour tension of saturated air at 36·5° C., and f = vapour tension of the air observed. From this equation the cooling power due to evaporation only $(H_w - H_d)$ is seen to be represented empirically by $(0{\cdot}08 + 0{\cdot}10\,V^{0\cdot3})^{\frac{4}{3}}$. It may be noted that 0·26 metres per second was the lowest observed velocity, but the mean experimental results agreed well with this equation up to 4 metres per second (9 m.p.h.) which is more than concerns mine ventilating engineers.

These formulæ (with more places of decimals than are given here) are based on tests carried out by Dr. Leonard Hill for his papers before the Royal Society and for his book, *The Science of Ventilation.* The experiments were made chiefly at East London College. Subsequent experiments which agreed well with each other were made at the National Physical Laboratory in their 4 ft. and 7 ft. wind tunnels, and at Oxford with a rotating arm machine. These tests may be taken as more reliable than the earlier ones, and give :—

For velocities greater than 1 metre per second :—

$$H_d = (0{\cdot}13 + 0{\cdot}17\,V^{0\cdot5})\theta.$$
$$H_w = (0{\cdot}10 + 1{\cdot}10\,V^{0\cdot5})\theta'.$$

and for velocities less than 1 metre per second (200 ft. per minute) :—

$$H_d = (0{\cdot}2 + 0{\cdot}4\,V^{0\cdot5})\theta.$$
$$H_w = (0{\cdot}35 + 0{\cdot}85\,V^{0\cdot5})\theta'.$$

where $\theta' = (36{\cdot}5°\,C. - t')$, t′ is the wet bulb temperature of air in degrees centrigrade, and V equals the velocity in metres per second.

These two latter formulæ expressed in feet per minute and degrees Fahrenheit become :—

$H_d = (0\cdot 11 + 0\cdot 016\ V^{0\cdot 33})\theta.$
$H_w = (0\cdot 19 + 0\cdot 08\ V^{0\cdot 33})\theta'.$

It will be observed that with the aid of the above formula the wet kata cooling power can be calculated if the temperature, vapour tension, and velocity are known. In the case of surface conditions the prevailing wet kata cooling power could be calculated from the published meteorological records if the wind was steady and the effect of sunshine was neglected. The effect of depth or increased barometric pressure is naturally to increase the cooling power. The percentage change in cooling power is approximately one-fourth the percentage change in pressure. The formula which has been checked by experiment is :—

$$H_2 = \tfrac{1}{2} H_1 \left(1 + \sqrt{\frac{P_2}{P_1}}\right).$$

Conversely cooling power decreases with altitude. At the altitude of the Rand where the pressure is about 20% lower than at sea-level the cooling power will be but five per cent lower than at sea-level, an amount which can be neglected for most practical purposes, particularly as the formula only applies to cooling in still air. For the case of the Rand Mr. H. S. Ireland gives the modified dry kata formula as :—

$$\frac{H_d}{\theta} = 0\cdot 26 + 0\cdot 44\ V^{0\cdot 5}$$
$$\text{or } H_d = (0\cdot 26 + 0\cdot 44\ V^{0\cdot 5})\theta.$$

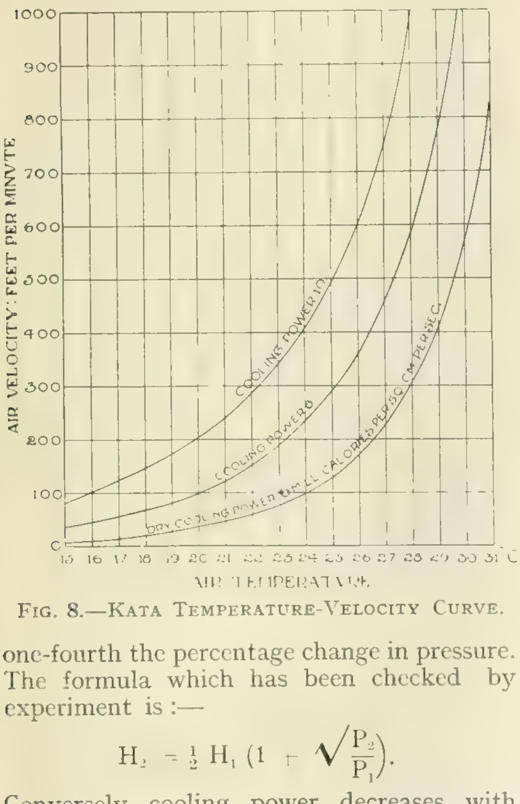

FIG. 8.—KATA TEMPERATURE-VELOCITY CURVE.

How cooling power varies with velocity and temperature is shown from the latest determinations in Fig. 8. Fig. 9 shows the curves connecting cooling power and velocity as arranged for the estimation of the latter.

APPLICATION OF THE KATA-THERMOMETER.—The most immediate use of the kata-thermometer in mining is for the purpose of investigating the cooling effect obtainable in hot mines from artificially produced air currents and the reduction of body clothing.

Mr. E. H. Clifford, in his paper on the City Deep (see Bibliography) shows what a useful guide kata readings may be when one has to deal with a saturated atmosphere. Kata readings do not give an exact index of physiological effect, but they do give actual cooling power, and that has been shown to be the chief factor influencing the capacity for physical work. On the City Deep a wet kata reading of 15 millicalories per square cm. per second was considered the lower limit for physical work, while 30 was taken as the upper limit. The best conditions for physical work without much clothing corresponded to a reading of 20. Wet kata readings were considered most because on this mine it is necessary to keep the air saturated for the purpose of allaying dust. The foregoing figures assume the absence of excessive velocity or excessive dryness, both of which are injurious, even though the wet kata

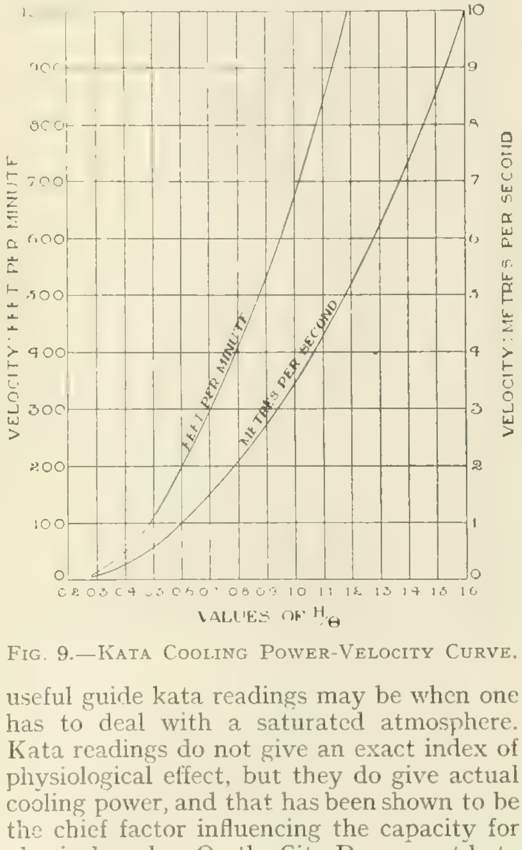

FIG. 9.—KATA COOLING POWER-VELOCITY CURVE.

reading be satisfactory. Where clothing is worn whether it be wet or dry profoundly affects the actual cooling power of any given air current on the body. With warm air this difference between actual and indicated cooling power is greatest with light wet clothing in dry air and least with no clothing in saturated air. Generally speaking, a wet kata reading of about 20 or a dry kata reading of about 10 indicates satisfactory conditions for physical work with little clothing. Dr. Leonard Hill gives dry 10 and wet 30 to 35 for manual work. Mr. H. J. Ireland finds 6 and 18 respectively sufficient for a slightly clothed native.

The basal metabolism of the average man when breathing 20 cubic feet per minute will correspond to a heat loss of about one millicalorie per square cm. of body surface per second. Waste may bring this up to three millicalories when breathing 60 cubic feet of air per minute. The rise of body temperature itself to about 102° F. during muscular exertion facilitates cooling considerably where conduction is relied on.

It is true that in the general ventilation of a mine a quantity of air sufficient to keep the mine at a low enough temperature must be supplied, as velocity cannot always be varied from place to place. But the kata-thermometer supplies the means of testing reliably where this velocity is too low or where the air has warmed up too much for efficient work as distinct from prevention of work. Such readings could well be marked on the mine's quarterly ventilation plan. An air current at nearly the same temperature as the body is far less noticeable than an appreciably slower one at a much lower temperature. This point is important in considering the comfort of the worker.

In the case of metal mines situated in places where considerable seasonal variation takes place in surface humidity and temperature and where the mine air is not saturated with moisture owing to the necessity for allaying siliceous dust, the kata-thermometer may be employed to effect great economies in the quantity of air required for efficient work. Owing to the comparatively few deep metal mines being worked as yet this has not been made the object of much study. The number of such deep mines must unfortunately increase greatly in the near future.

In such cases a continuous record of the cooling power of the air in the main levels might be found of value. For such purposes an instrument called a "Caleometer" has already been designed by Dr. Leonard Hill and Mr. O. W. Griffith. It is an electrical instrument which automatically measures as electrical energy the amount of heat energy required to keep a small coil of wire at body temperature, and, therefore, can record the cooling effect of the air current in which the coil is placed. (This instrument is made by Robert W. Paul, of the Newton Avenue Works, New Southgate, London, N.) The record of up to eight coils in different places can be taken on the same roll. For a record corresponding to wet kata readings the coil is surrounded by a tape hanging in a pot of water. The ordinary kata-thermometer is also made in a recording form by the same company.

Actual observation (Daniel Harrington) on the miners themselves has shown that a minimum air velocity of 25 ft. per minute is most desirable in even cool dry mines (dry bulb temperature of 75° F.) for efficient work, but that a velocity of 100 ft. per minute is required where the humidity is over 85%. In hot wet mines a velocity of over 500 ft. per minute may be required. It was found that men could work without inconvenience in velocities as high as 1,000 ft. per minute, and this in spite of an oxygen depletion of 1% (the air containing 20% oxygen instead of 21% as at surface) and a CO_2 content of 0·30% or more.

The utility of the kata-thermometer for checking such results is great, particularly where saturated air at about blood temperature has to be used and is circulated at high velocities by small fans and canvas tubing. A reduction of the relative humidity from saturation by even a small amount, say to 95%, renders the effect of velocity far more pleasant to the worker. The subject of retaining such a reduction without interfering with the allaying of dust was dealt with in the discussion on Mr. Clifford's paper before the Institution of Mining and Metallurgy (March, 1921), and is a matter which requires investigation more urgently the deeper and hotter our mines become. Such investigations are rendered far easier of prosecution by the invention of the kata-thermometer. In Mr. Harrington's paper (p. 21) on Ventilation and the Use of Small Fans (see Bibliography) this instrument does not seem to have been used. In another paper on the use of booster fans where the air was above blood temperature, the wet bulb temperatures were taken as the index of cooling effect and

the volume of air necessary to keep down this temperature was measured. The amount found necessary was 600 cubic feet per man per minute, instead of the 400 cubic feet used elsewhere in the mine. Of course, where the general, as distinct from the local, ventilation of a wet mine is increased, a slight reduction of temperature is caused by the concomitant increase in the quantity of water evaporated underground to give a saturated condition of the air. Only 0·30 grm. is required to cool one cubic metre of air 1° C. Mr. C. Mezger gives the following example to show the order of effect to be expected from this cause. Assuming the temperature at bank and shaft-bottom to be respectively 10° C. and 19·5° C., and the saturation 90% in both cases, the absorption of moisture per cubic metre of air will be 6·6 grammes consuming 3·96 calories: the temperature will therefore be lowered 13·2° C. Auto-compression in the shaft and friction and conduction throughout the mine have a warming effect. Therefore the actual reduction in air temperature is naturally less than the calculated fall. The effect on the body of air temperature (but still more of velocity) is, of course, modified by clothing as it hinders both evaporation and conduction. This can be investigated quantitatively by the kata-thermometer. The instrument, with a light wire shield, can readily be placed between the skin and the clothing of a man. The heat loss of the human body lightly clothed is approximately one-sixth of the dry kata cooling power where this is normal, and is about 60% of the heat loss of the naked body. In estimating the total heat loss advantage may be taken of the empirical rule: surface in square metres $= 0{\cdot}123\,W^{\frac{2}{3}}$ for men where W is the weight in kilogrammes, but the subject is a rather complicated one. In Chapter VIII, Vol. II, of *The Science of Ventilation*, Dr. Leonard Hill gives a summary of the present knowledge on this subject, but in the case of hot and deep mines it may be assumed generally that for manual work clothing will be discarded.

In connexion with the subject of kata cooling powers interesting tests have been carried out (Zuntz) on the amount of water vapour (perspiration) lost from the body during exertion. In tests on a number of fully equipped men in uniform the thinnest only lost 953 grammes, while the fattest lost 2,575 grammes of moisture. Taking 800 grammes loss per 1,000 calories expended in saturated air at 50° F. as the standard, the amount was diminished 4 grammes for each 1% reduction in dryness and 70 grammes for each unit increase in wind velocity (on a scale of ten units). A rise in temperature increased the loss by only 0·2 grammes per degree Fahrenheit.

These tests confirm the importance of velocity as shown by the kata-thermometer, but also show that at moderate temperatures training has a far greater influence than either humidity, velocity, or change in temperature. This is curious considering how many a good old Cornish miner is not exactly slim. Still, fatness is partly a thermal reserve for heavy work, and is not entirely due to lack of fitness. A normal man carries about 18% of fat, which on a weight of 11 stone corresponds to a thermal reserve of about 12,000 calories, three days full food supply.

As temperature increases the influence of humidity and velocity on perspiration becomes greater in proportion, so that the taking-off of clothes is essential in hot places in order to obtain full advantage of the ventilation. Where cooling by conduction and convection has to be relied on this is even more necessary, as the clothes hold a layer of insulating air in contact with the skin. (See *Science of Ventilation*, Vol. II.) Different materials act differently in this respect.

Application of the Ergometer.—With regard to the individual efficiency of work performed in hot and deep mines, the working efficiency of the miner is not only affected by the temperature, velocity, humidity, and composition of the air in which he works and by the approximation to optimum effort which he exerts and by the amount and condition (wet of dry) of his clothing, but also by his fitness and stamina, as influenced by his health, general hygienic conditions, diet, acclimitization, physical training, and individual idiosyncrasy. Interest in the work, contentment, and an adequate wage, combined with the absence of any artificial enhancement of his standard of living (for instance, meat, boots, and bicycles for Kaffir boys) are also necessary factors. The length of time worked underground and the number and duration of rests during the shift also affect the efficiency on a given output.

Of the above factors only those dealing with adequate ventilation can be measured with the kata-thermometer. The remaining factors at first appear hopelessly numerous and diverse, but their sum total effect can be estimated by means of measuring the

mechanical efficiency of the man and his degree of liability to fatigue. Fatigue is here used in the medical sense to mean that condition of the body which results from too heavy a demand for physical work having been made on it, that is a load which has caused an additional consumption of actual nitrogenous muscular tissue as distinct from a mere oxidation of the stored fat and

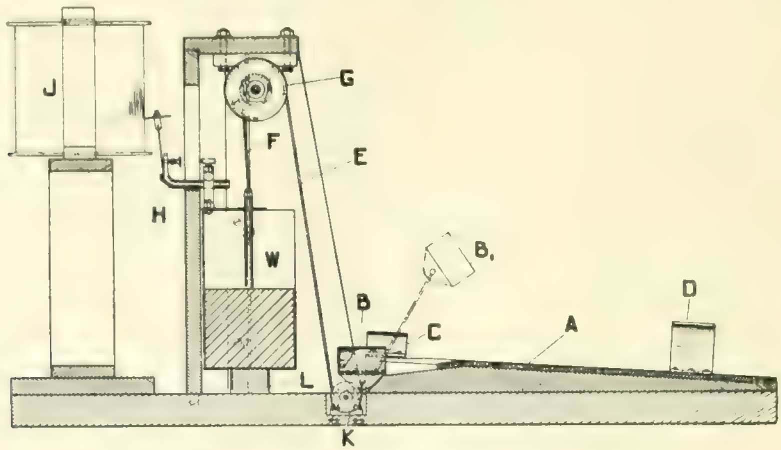

FIG. 10.—ERGOMETER FOR MUSCULAR FATIGUE

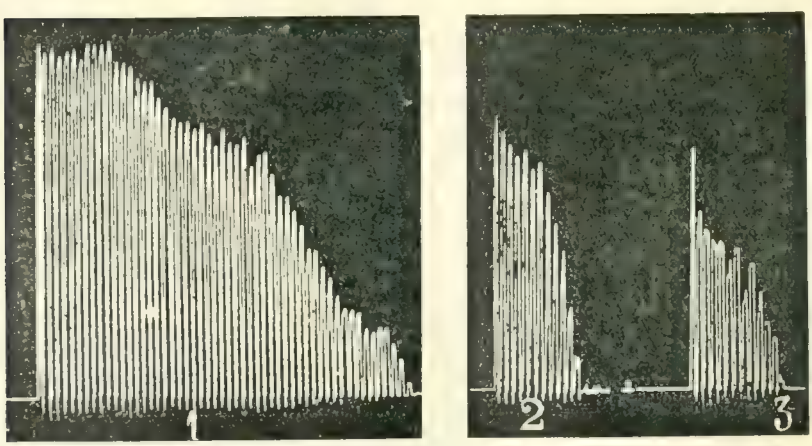

FIG. 11.—ERGOGRAPHS.

carbohydrate (glycogen). Nervous fatigue, the saturation of the blood with CO_2, and the production of lactic acid and other deleterious substances in the blood from only partially oxidized tissues are other physical accompaniments of fatigue. When fatigue has commenced a man is positively unable to work at his proper efficiency, and his expenditure of physical and nervous energy on a given amount of work increases continuously. If rest, sufficient to allow for the restoration of the purity of the blood, is not allowed, general fatigue results, which affects the whole body and may even cause death. Dr. Orenstein says the chief results of over-fatigue " are lassitude, loss of mental alertness, craving for stimulants, decreased resistance to disease, increased liability to chill, nervous irritability, discontent, and an enormous lowering of efficiency in the performance of work."

Hence the determination of the conditions causing fatigue must go hand-in-hand with determinations of mechanical efficiency, and are particularly important in determining the fitness of a man for special exertion, as in mine-rescue work or hand-drilling.

An absence of protein in the diet is one cause of fatigue. Protein was for long

regarded chiefly as a fuel for the muscles, and 100 grammes ($3\frac{3}{4}$ oz.) per day was laid down as the minimum necessary. Its function is really to replace worn muscular tissue. It has been shown (Cathcart, 1912, p. 109) that so long as the task does not result in excessive fatigue (overload) no *increase* of nitrogen content can be detected in the urine as due to such work, although it has often been stated that the nitrogen content of the urine is proportional to the amount of work done. Hindhede (1913), of the Nutrition Institute of Copenhagen, carried out observations on a man (11 stone in weight) who worked as a mason and labourer for 95 days on a diet containing only $1\frac{1}{2}$ oz. of protein equivalent to only 170 calories out of a total of 5,000 calories, the energy value of his daily diet. Its "specific dynamic energy" certainly makes a larger ration desirable, but such a ration does not prevent an increase of the nitrogen content of the urine being used as an index of overload on the human machine, nor make the nitrogen content proportional to the total work done.

The most direct method (Fig. 10) of determining muscular fatigue (see Mosso's book on Fatigue) is by the use of ergographs or charts showing the time taken to completely fatigue a given set of muscles by repeatedly contracting them, and also showing the relative force of the contraction for a given amount of energy in each contraction. In Fig. 11, it is seen that fifty-two contractions were performed before the muscles were completely fatigued. Two hours were required for complete recovery. If only half the number of contractions had been performed the muscles would have required but one-quarter the time to recover; moreover, the amount of work performed would have been not half, but approximately two-thirds of the whole (see Dr. Orenstein's paper). The application of such results to manual labour problems is obvious. The acceleration of fatigue by rise of temperature can also be tested in this manner, but such results give local not general fatigue, and do not indicate the degree of mechanical efficiency.

From what has been said earlier in this article, it might be expected that increased consumption of protein would also be indicated by a fall in the R.Q., and that this fall would afford an index of fatigue, but this is masked in practice by a quite large drop in the CO_2 content of the expired air, due to the lung ventilation being incapable of supplying the increased demand of the over-loaded human machine for oxygen, and also due to the dilution of the expired air by hard panting. On normal heavy loads oxygen-want causes quick and rather shallow breathing, owing to the effort to get an increased volume of air into the lungs. Similarly on overloads in normal air oxygen-want causes the same effect. A high atmospheric content of CO_2 on normal loads, be it noted, causes deep, slow breathing, due to the effort to obtain greater pulmonary ventilation.

It is for these reasons that plotting the percentage of CO_2 in the exhaled air against load gives such useful results when the ergometer is being used in conjunction with determinations of the Respiratory Quotient for estimating the mechanical output and efficiency of an individual.

The percentage of CO_2 in exhaled air increases with the load from about 4% up to about 7% on full load; if the load be increased further the percentage of CO_2 falls for the reasons already mentioned. Hence, on plotting the results obtained for a given individual a dome-shaped curve is obtained. (See Fig. 12, next page.) The rate of doing work indicated at the crest of this curve makes the change from load to overload and the commencement of fatigue; that is, the man can sustain loads up to the crest load for some considerable time, as his oxygen input is adequate to deal with such rates of work, but he can only bear loads slightly above the crest value for a short period. (Second Mining Rescue Apparatus Report, p. 55.)

The most remarkable thing about such curves is the striking way in which they show not only the strength and the stamina (power of supporting sustained physical effort) of a man, but also his degree of fitness (physical training for heavy work). This latter is arrived at by testing the man with both ordinary and oxygen-enriched air. When ordinary air is breathed during exertion the man in good physical training exhales a higher percentage of CO_2 and a lower percentage of oxygen, and also breathes less air for a given consumption of oxygen or output of work than does the man in bad training. The fit man not only works at a higher food efficiency, but, on a given load *more completely utilizes* the air he breathes. But when he is tested with enriched air he shows but little increase in the CO_2 content of his flue-gases. In fact, enriching the

oxygen above 60% seldom gives any advantage at all with a fit man.

A man who is in bad training, on the other hand, immediately responds on load to enrichment of the air supply, and on pure oxygen almost catches up the trained man, so far as his thermal efficiency is indicated by the percentage of CO_2 expired. The crest load of a man on ordinary heavy work (4,800 ft.-lb. in Subject I and 6,400 in Subject II, Fig. 12) is sometimes expressed as a percentage of 10,000 ft.-lb., an arbitrarily chosen crest load, and called his percentage fitness. This is a purely relative figure. A more useful method of expressing the fitness of a subject is to divide the crest ordinate of the air-curve by that of the oxygen curve, 3·75% CO_2 being chosen as the datum level

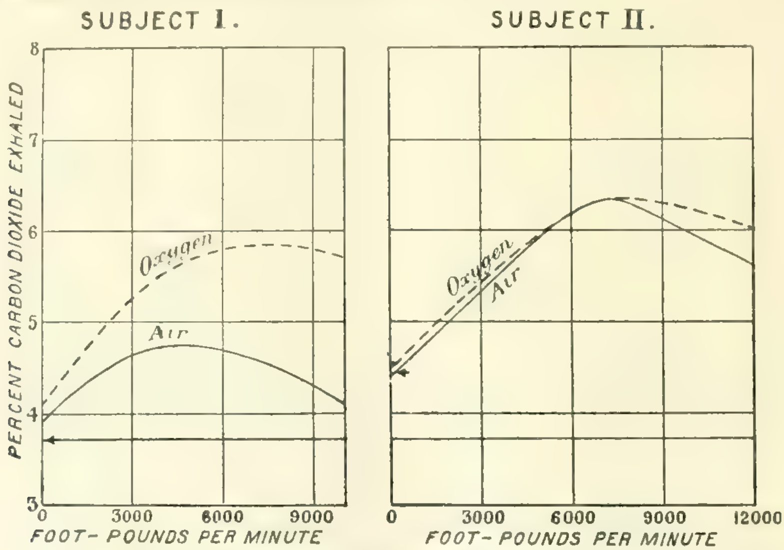

FIG. 12. ERGOMETER CURVES

from which to measure. By this method the fitness of Subjects I and II are 46% and 100% (a sedentary person and a specially selected instructor in physical drill respectively) instead of 50% and 70% by the arbitrary method. By the former method the fitness of a healthy working miner is generally about 75% (Briggs). This method of measuring fitness by physiological response to oxygen during muscular exertion really tests the fitness of the lungs alone. Where these are fit the rest of the body is generally fit, but apart from this the test is particularly valuable in mine-rescue work and in determining the fitness of a man for work in high altitudes or at great depths.

With regard to the thermal efficiency of the human machine, as distinct from fitness, determinations with the cycle ergometer by Professor Henry Briggs give a figure of about 23% crest efficiency for average citizens, and 33% for fit, trained, manual workers; 37% is his highest recorded figure. The average of Professor Langelois' determinations in France is about 33%, while Benedict and Cathcart got about 33% quite independently in America. This is a high figure compared with a steam engine at 12%, but the human machine cannot maintain crest loads for 24 hours a day. The steam-engine, on the other hand, requires no sleep.

Professor Waller and Miss G. de Decker have gone somewhat further (see Bibliography), and have investigated the physiological cost of muscular work in various different industries, and the calories consumed per square metre of body surface per hour on both piece work and time work.

Determinations on the cycle ergometer, combined with observations of the R.Q., may thus be most useful in mining work for testing not only the strength of a man but also his capacity for heavy exertion and the amount by which his output can be increased by training. The value of such tests for men in the Army has been recognized in France, where tests are made on the capacity of men to march at varying speeds with different weights of equipment in flat and hilly country. A travelling escalator belt, whose inclination and speed can be varied, is used so that the man marching

remains at a constant distance from the CO_2 recorder (Professor Langelois).

In mining, working efficiency tests, as mentioned, already find a use in testing men for mine-rescue work and for work at high altitudes. The greatest practical use for such tests seems to be on the one hand for determining the effects of diet, training, depth, temperature, and adequate ventilation on the working efficiency and stamina of selected men, particularly with a view to employment in hot and deep mines, while, on the other hand, such tests should be useful in testing the efficiency and fitness for mining work of freshly recruited white labour and of natives from new areas. The old method of trial by death rate on large batches of native labour recruited from new areas is, at times, troublesome and expensive.

A study of the amount of effort expended is the first step after hygienic conditions have been obtained, then the optimum effort and the rests and amount of work per shift. After that comes the basic economic question: does the human machine pay better than electricity or compressed air under the given circumstances ?

One of the simplest cases in which it does not as a rule pay is that in which the human machine is used instead of mechanical haulage for taking men to and from their work in deep mines. It is for the mining engineer to decide this.

In the words of one of our greatest pioneers in this new branch of mine engineering, the effect of physical conditions on human working efficiency: "It is felt that both the apparatus and the theories have reached a stage of development in which they can be presented to the mining world for verification and modification."

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Herewith is a list of books and papers that may be consulted in studying this subject. Papers particularly useful to mining men are marked with an asterisk.

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*Ventilation in Metal Mines. By D. Harrington, Bureau of Mines, Department of Interior, U.S.A. Technical Paper, No. 251, 1921.

The Kata-Thermometer.

*The Kata-Thermometer and its Practical Uses in Mining. By H. J. Ireland. *Journal* of the Chemical, Metallurgical, and Mining Society of South Africa. Vol. xxi, November, 1920, p. 84.

*The Science of Ventilation. By the Medical Research Committee (Dr. L. Hill). H.M. Stationery Office. Vol. i, 1919, 10s. ; vol. ii, 1920 (Theory), 6s.

*Report on Ventilation and the Effect of Open Air and Wind on the Respiratory Metabolism. Local Government Board, 1914. H.M. Stationery Office, 9d.

Dr. Leonard Hill's paper in the Phil. Trans. Royal Society. Series B, vol. ccvii, pp. 183–221, or separately as B. 339, price 3s. See also "The Effect of Velocity on Cooling Effect," pp. 198-203, and "Heat Loss at Body Temperature by Convection, Radiation, and Evaporation."

The Kata-Thermometer [illegible] September 1?, 1921, p. 387.

*Some [illegible] work in the City Deep Mine at a depth of 7,000 ft. By E. H. Clifford. Institution of Mining and Metallurgy, Bulletin 197, February, 1921; Discussion, Bulletin 198, March, 1921.

The Comfort Meter Leaflet. Given by James J. Hicks, of 8, Hatton Garden, E.C., with the Kata-Thermometer, when purchased.

In the foregoing works various useful references to the *Journal of Physiology*, the *American Journal of Physiology*, the *Proceedings* of the Physiological Society, the *Proceedings* of the Institute of Hygiene, and the *Year Book* of the Carnegie Institute, will be found. A short bibliography of the subject is given by Dr. Leonard Hill in the Philosophical Transactions of the Royal Society already quoted.

Among the chief actual workers on this subject are Dr. Leonard Hill, F.R.S., of the Medical Research Council, Professor Henry Briggs, D.Sc., A.R.S.M., of Edinburgh, Dr. J. S. Haldane, F.R.S., of Oxford, Sir John Cadman, of Birmingham University, Professor E. P. Cathcart, D.Sc., of Glasgow, Professor Waller, of the University of London (The Industrial Research Board), Professor Martin, of the Lister Institute, and Professor Macdonald, late of Sheffield, now Professor of Physiology at Liverpool. In America Professor F. G. Benedict and Dr. W. Atwater have done much laboratory work on this subject at the Carnegie Institute, Boston, for various United States Government Departments.

The pioneer workers on the application of this work to metal mines are Dr. A. J. Orenstein, C.M.G., M.D., etc., and Mr. H. J. Ireland, M.B.E., B.Sc., of the Transvaal Chamber of Mines.

New papers by any of the above authors on the subject of Ventilation and Efficiency can be relied on to be of interest to mining engineers.

BOOK REVIEWS

Concentration by Flotation. Compiled and edited by T. A. Rickard. Cloth, octavo, 690 pages, illustrated. Price 42s. net. New York: John Wiley & Sons; London: Chapman & Hall, Ltd.

Just as there have been continual legal and commercial disputes about flotation, so have there been plenty of antagonistic views among writers in the Press and among compilers of books, when dealing with this subject. Most of the literature so far made accessible to the public has come from the United States or from American authors, and the views expressed and the information given by these writers are almost always unfavourable to the status of Minerals Separation, Ltd. This company has secured the validity of its patents in all the courts of the world, after very lengthy arguments, so that *ex parte* statements in the Press and in books with regard to the history of the invention no longer really serve a good purpose. On the other hand, the fact that Minerals Separation exercises its monopoly to the fullest extent allowable by law, naturally raises considerable opposition and ill-feeling among its past and present enemies, so that post-patent agitation arises urging that the possession of such a monopoly is contrary to public policy. It is also questioned whether the ownership of patents by a corporation which means to derive its benefits entirely from licences was contemplated when the original patent laws were drawn up. Thus the opponents of Minerals Separation would wish to put the company in the position of Shylock, who is first told that the "law allows it and the court awards it," and afterwards is informed that if he, an alien, attempts to collect his dues, he will be outlawed for conspiring against the worthy citizens of a great State. No doubt in many quarters there is an outcry against the business and legal methods of Minerals Separation; but after all the law is on its side, and that not through any accidental circumstance.

We have said that most of the literature on flotation comes from the opposite camp. Much of it is published with the intention of belittling the claims of the patentees to greatness; some is published to give helpful information as regards both practice and theory; and some is obviously intended to draw discussion and obtain records of experience from other investigators. It is a pity, of course, that Minerals Separation does not allow its engineers, chemists, and physicists to write articles for the Press and to publish records of experiments and authentic accounts of the origin of the various improvements in the process, for thus many lacunæ would be filled and there would be a variation in the atmospheric effects. King John and Louis XI suffered in the estimation of posterity because they allowed

their enemies to write the history of their times without protest or counterblast; in the same way Minerals Separation takes no steps to tell the true and full inside story of the development of flotation.

Thus it comes about that we have a book on flotation, edited and compiled by Mr. Rickard, which is like the play of *Hamlet* without the Prince of Denmark as one of the characters. There is a vast amount of history, theory, and practice in its pages, but being written without the aid of the chief inventors and investigators there are many places where the information is incomplete and even inaccurate. Moreover, the arguments and the interpretation of the history are admittedly and obviously hostile to Minerals Separation and its technical staff. If the reader bears the foregoing remarks in mind he will find much useful aid and help in the pages of the book. It must also be mentioned that as the book consists of a reprint of a great variety of articles by many authors published in the *Mining and Scientific Press* during the years 1915 to 1920, the quality of the reading matter is variable, and separate sections are occasionally contradictory, no attempt having been made to co-ordinate or reassemble the subject matter of the articles.

In all forty articles have been reprinted in this book. Of these eight are contributed by Mr. Rickard, while other well-known names in the list of contributors are Ralston, Glenn Allen, Clennell, Hebbard, Shellshear, Henderson, Evan Simpson, and Coghill. Mr. Rickard writes on the history of flotation, the principles of flotation, and flotation litigation. He also contributes descriptions of practice at Utah Copper and of the smelting of flotation concentrates at Garfield. There are articles on testing ore for flotation, the disposal of flotation residues, the flotation of oxidized ores, the Bradford process, the Horwood process, the flotation of silver ores, the cyanide treatment of flotation concentrates, and several others of similar practical character. The remaining papers deal with the theory, and this section of the book is the weakest.

To proceed now to a few details that deserve criticism. In the first place the glossary at the beginning of the book is quite unworthy of the subject, and the reader is apt to wonder whether the errors are due to ignorance or to blunders on the part of the stenographer and the typist. It is surely not necessary to define such words as buoy, skin, scum, agitation, emulsion, molecule, grease, froth, pulp, metallic, gangue, bubble, fat, and film. With regard to "skin," this word is said to be derived from the Anglo-Saxon "scinn," ice. The word "ice" has been copied from an etymological dictionary, and should be "Ice.," which is a contraction for "Icelandic," and evidently refers to the remainder of the quotation from the dictionary, which has been lost during its transmission to the glossary. The definition of oleic acid given in the glossary says that it is the "fatty acid contained in olive oil combined with cresoline." Presumably "cresoline" should read "glycerine," but even so olive oil is not combined with glycerine. Then, again, the word "flotation" is said to be derived from the French "flottaison," the meaning of which is given as "water-line." This is not the meaning of the French word. Anyway the English word was not derived from the French, but was invented at home.

When we get to the definitions of the more technical words such as colloid, adsorb, surface-tension, and gel, all we need say is that most physicists will not agree to the wording.

In Mr. Rickard's history of flotation we miss any reference to Jason's expedition to capture the Golden Fleece, which is generally held to indicate the accumulation of gold particles on sheep-skins placed in the auriferous rivers of Asia Minor during flood-time. Then, again, it is impossible to accept the statement that it is due to the "patient empiricism of Hoover, Callow, and other technicians" that flotation was developed as a workable process, for, as a matter of fact, Mr. T. J. Hoover was engaged by Minerals Separation some time after the process had been proved to be a success, while Mr. Callow only appeared on the scene in 1913. If the expression "and other technicians" had been expanded, and the names of, say, Moulden, Hebbard, Chapman, Bradford, Horwood, Broadbridge, and Shellshear had been added in front of Hoover and Callow, the real case would have been presented. Another statement in this section of the book to which exception may be taken relates to the origin of the slide machine used in testing. Mr. Rickard says that this "machine was designed by Hoover and perfected by many others." As a matter of fact, the machine was designed by Mr. Sulman, and the first was made by Mr. Picard before Mr. Hoover had any

connexion with flotation. This original machine was exhibited in evidence during the litigation in the United States.

As has already been said, the sections of the book devoted to the theory and physics of flotation are the weakest. Here we miss any article by Dr. Wilder D. Bancroft, who knows more about the subject than anyone else in the United States. There are brief references to Dr. Bancroft's evidence against Minerals Separation in the American litigation, but a summary of his evidence, or, better, a special article by him, would have added greatly to the value of the book.

The theory of flotation demands an extensive acquaintance with the most intricate problems in physics and chemistry, and as the articles on flotation in the volume under review have not been written by trained physicists, a high standard of accuracy could hardly be anticipated. For the most part they have been written by authors who are groping after an elementary knowledge of the scientific aspect of the question. Perhaps the best paper is that on "Molecular Forces and Flotation," by Coghill, but much of this article is devoted to exposing fallacious statements which could scarcely be entertained by anyone conversant with the fundamental laws of physics. It is noticeable that Coghill gives a fairly accurate account of the mechanism involved in the flotation of solids denser than water at the surface of water; his explanation serves to show that these particles do not float by adsorption.

Anderson's paper contains a number of mis-statements, a few of which may be mentioned. On page 286 it is stated that "a bubble of air is spherical in shape, and this shape can only be maintained if the external pressure exceeds the internal pressure." The reverse is the fact; of course, the *internal* pressure must *exceed* the external. On page 278 it is stated that "all acids will lower the surface-tension of water." Röntgen and Schneider have found that as the concentration of sulphuric acid in water increases the surface-tension rises, until the liquid contains about 48% of acid, and then decreases as the concentration of the acid increases. A 70% solution of sulphuric acid in water has a surface-tension almost identical with that of pure water. This statement is not a mere slip, as the action of acid is likened to that of oil on page 279.

Hardy Smith's paper contains many wild and misleading statements. The statement (page 269) that "the surface of the liquid in contact with the particle must be considered as tending to have surface-tension, although the tendency is opposed by the adhesion" is really quite incomprehensible, although Hoover's book on Concentrating Ore by Flotation is quoted in support. The statement (page 271) that contaminating agents are added so as to counteract the difference in vapour pressures of large and small bubbles in order to prevent them from coalescing, has also no foundation in fact; a contaminating agent will reduce surface-tension of a bubble and so slightly reduce the pressure of the gas contained therein, but its effect on vapour pressure is negligible. The statement that the surface-tension becomes zero at the boiling point (page 273) is, of course, quite inaccurate, and is contradicted by Coghill on page 302. On page 275 we find the statement: "As soon as a bubble has expanded to an appreciable size, the vapour pressure of the liquid is in excess of that necessary to balance the surface-tension, and the bubble expands so rapidly that it literally explodes." No such explosion occurs, and the vapour pressure of the liquid has nothing to do with the stability of a bubble. On page 274 diagrams are given showing mineral particles enclosed in bubbles just as they might be in glass bulbs; elementary observation shows that such conditions never occur.

Mr. Rickard's article on the Principles of Flotation contains several very questionable statements. There can be no doubt that the surface layer of a liquid, instead of being denser than the rest of the liquid, as stated on page 57, is really less dense. The statement (page 61) that, when an alcohol is added to water, the change of viscosity enables a froth to be formed, cannot be supported. The stability of an armoured bubble (page 63) is not due to viscosity. This can be understood best by a simple analogy. It would be impossible to build a bridge using only liquid cement, but, by the aid of stones, the building of the bridge is rendered easy. The statement, page 73: "Any substance that will lower the surface-tension of water and be adsorbed by mineral particles would appear to promote flotation" is not correct; some substances, such as tannic acid, do both, with the result that flotation is rendered impossible. It is stated on page 75 that "the needle that floats on tap-water will sink in distilled water; although contaminants have lowered the

surface-tension of tap-water, it has more sustaining power on account of its aeration." As a matter of fact, a needle will float on distilled water, if this is not contaminated by grease, as often is the case, and the surface-tension of tap-water is not lower than that of distilled water; finally, the sustaining power derived from aeration is a myth. On page 77 is found the statement: "No longer is the mineral supposed to be buoyed by the bubbles, as if tied to a cork, but the minute particles of mineral are believed to be drawn into the bubble film." This statement is in direct contradiction with the explanation given by Coghill; it also involves a still more fundamental fallacy. In a footnote on page 76 it is stated that the layer of liquid subject to surface-tension has a thickness less than the radius of molecular action, and the "bubble film" mentioned by Mr. Rickard obviously refers to the layer subject to surface-tension. Various estimates of the radius of molecular action have been given, and these vary between 10^{-8} cm. and 10^{-6} cm. According to Langmuir's recent theory the layer responsible for surface-tension is only one molecule thick. Taking, however, the largest estimate of the thickness of a surface-layer, namely 10^{-6} cm., the diameter of a slime particle that could pass through a 200-mesh screen would be about five thousand times as great as the thickness of the bubble film into which it is believed to be drawn.

Instances such as those given above could be multiplied, but, without going further, it will be conceded readily that explanations involving so many mis-statements of fundamental principles which could have been avoided by reference to ordinary text-books on physics are not likely to carry much weight.

☞ Copies of the books, etc., mentioned under the heading "Book Reviews" can be obtained through the Technical Bookshop of *The Mining Magazine*, 724, Salisbury House, London Wall, London, E.C. 2.

NEWS LETTERS

PERTH, W.A.

October 20.

OIL IN KIMBERLEY DISTRICT.—Much has been heard of the discovery of indications of petroleum deposits in Kimberley district, in the north-east section of West Australia. A statement has been made on this subject by Professor Sir Edgeworth David, who has recently been making investigations. This statement is the first connected and reliable account of what is going on, and, moreover, it discusses the find in conjunction with other investigations elsewhere in Australia. It is therefore worth quoting in full here.

The area so far preliminarily tested is at Price's Creek, to the east of the junction of Christmas Creek with the Fitzroy River. This is approximately 200 miles south-west of the area where the asphalt glance has been found, and about 160 miles in a direct line south-east from Derby, and roughly 250 miles south-west from Wyndham. At Price's Creek indications of oil are now forming in small seepages which yield a distinct smell of petroleum. At one spot on the Rough range in this vicinity the grass will not grow on account of the oil seepage.

While Mr. Blatchford was at Price's Creek Mr. Freney had a bore put down by hand on the adjacent hill to a depth of 90 ft. Mr. Blatchford watched closely the minutest details of this boring, and collected all the samples and brought them under seal to Perth. There they were tested by Dr. Simpson, who found that true mineral oil was present, although in small quantities, the proportion increasing slightly with depth. The mineral oil is there contained in sandstone and thin limestone. The actual weight of the oil compared with that of the rock is only one part in 4,000, but this relatively small amount should be sufficient to supply quantities which under favourable conditions for concentrating and observation may be sufficiently extensive to be of economic value.

As regards the structure of the Kimberley oil-bearing region, Mr. Blatchford's observations and reports show that broad gentle arches exist over a very wide area in this district. For example, at Mount Wynne, which is about 100 miles west-north-west of Price's Creek, there is an anticlinal arch upon which is situated a hot spring, with a temperature of about 110° F., yielding continuous bubbles of gas. It is not yet certain that this is oil gas, but it is certain that the anticlinal structures extend throughout the whole of the area between Price's Creek and Mount Wynne. Tests are being made of this gas.

As regards the geological age of the strata at Kimberley which have yielded traces of oil and asphalt, Mr. Blatchford considers

that they are of Lower Carboniferous age, that is, of an antiquity greater than that of the coalfields of Newcastle, Irwin River, the Collie, and so on, and probably at least six times as old as the water-bearing strata in the great artesian basin of Central Australia. In this latter basin at Roma, Queensland, a considerable volume of natural gas has been evident at intervals for many years past. Mr. Henderson, the Government Geologist of that State, has said that while the bulk of the gas is methane, there is also present some gas derived from petrol. Mr. Cameron, the Assistant Government Geologist there, has spent some time investigating the question, and he is strongly of the opinion that there is oil under Roma. The gas, however, was tapped at a depth of no less than 3,700 ft. below the surface, and as artesian water in considerable volumes was struck at a higher level, it was found extremely difficult to materially reduce the great pressure of water in this bore so as to admit of the gas forcing its way to the surface without hindrance. If oil really exists in this region, and the pressure of the gas is insufficient to lift a column of water 3,700 ft. high, it will be necessary to take measures to seal off the artesian water in future boring, so that the gas may be allowed to rise.

Expressed in terms of actual years, the Roma deposit may date back to the order of something like 50 millions of years ago, while that of Kimberley would be at least 300 millions, but the great antiquity of this area does not preclude the possibility of oil occurring in probably payable quantities. In North America and Canada large important oilfields are found in rocks not only of the Lower Carboniferous age like those of Kimberley, but in even older rocks such as the Devonian, Silurian, and Cambrian, while the indications at Kimberley, both as regards the genuine mineral quality of the oil and the structure of the rocks containing it, appear to be quite feasible.

To judge by the reports of Mr. Maitland and his officers, the public may be cautioned against assuming that necessarily there will be a payable oilfield in that region. In many parts of the world, for example in New Zealand and Papua, even stronger indications of oil have been known to exist for some scores of years, and yet up to the present all attempts to work these deposits successfully have failed. In the case of Papua there is no question that there exists a continuation eastwards of the great oil belt, only perhaps about a tenth as old as that of Kimberley, which runs from Burma through Sumatra, Java, Borneo, and Timor to Dutch New Guinea and Papua. There are numerous actual oil-bearing springs and oil-gas wells in Papua. According to Mr. Blatchford's examination the Kimberley region is far more settled in its structures than that of Papua and so should have the advantage over the latter region.

The next step to the possible development of Kimberley should be an immediate careful geological survey to locate at once the most favourable anticlinal arches for prospecting operations. Many oilfields have been given a bad name through hasty prospecting in wrong places. So soon as this survey by competent geologists shows the most favourable lines for boring, bores should be put down, and a plant provided capable of drilling to considerable depths. If necessary, the boring should go to some thousands of feet. The discovery at Kimberley, so far as is known, is the first recorded occurrence of true mineral oils in Australia, and while caution is needed, the prospects from a geological point of view appear to be distinctly encouraging. If payable oil is struck there anywhere, it will probably be found to extend over a considerable area.

Further interesting and encouraging information regarding the prospects of discovering mineral oil in the North-West is contained in an interim report by the Assistant Government Geologist (Mr. T. Blatchford) on what is known as "Oakes's Find" in North-East Kimberley, which was laid on the table in the Legislative Assembly on October 11 by the Minister for Mines, Mr. J. Scaddan. After explaining at the outset that Oakes's Find is situated about half a mile up the Negri River from the junction of that stream with the Ord River, about 1½ miles down stream from the spot where the Ord River Station–Wyndham Road crosses the Negri, the report proceeds to deal extensively with the geology of the neighbourhood. Later, Mr. Blatchford points out that the find was first brought to departmental notice by Mr. Oakes forwarding samples of glance pitch. That discovery, says Mr. Blatchford, is certainly the most definite surface indication of mineral oil residue that has been found in West Australia. There is every reason to believe, he says, that the pitch has come in the form

of mineral oil from unexposed underlying beds, which has, by a process of inspissation, left the pitch residual behind filling the cavities in the rock through which it has migrated. The question now is to ascertain whether the oil still exists, by means of a systematic survey.

TORONTO

November 9.

PORCUPINE.—The mine managers have for some time been anxiously considering the power situation, fearing a repetition of the experience of last winter, when operations were greatly curtailed owing to a shortage of electric energy. These apprehensions have been allayed, so far as the near future is concerned, by the official announcement of the Northern Canada Power Co. that they have now sufficient water in storage to supply the Porcupine mines with power until the end of March. A big dam has been completed near the head of the Mattagami River, which will back up the water for about 30 miles, and raise the level about 10 ft. While an ample supply may thus be assured for present requirements, it is realized that the existing sources of supply are inadequate to meet the greatly increased demands resulting from the steady expansion of the gold-mining industry, and that the projects of leading companies for greatly increasing their output cannot be carried out unless more power can be secured. The question is now being closely considered by the power company and the mining interests concerned.

The Hollinger Consolidated during October treated 108,024 tons of ore, being an average of 3,858 tons per day. The management has planned the sinking of a six-compartment shaft to a depth of approximately three-quarters of a mile, considerably lower than has hitherto been attempted in connexion with Canadian gold mining. It is proposed to increase the capacity of the mill to about 6,000 tons of ore daily by a change in the grinding equipment, replacing the 200 stamps now used with ball mills. The company is now employing 1,970 men, and has upwards of 100 machines in operation underground.

A statement covering the operations of the Dome Mines for the six months ended September 30, shows a total income of $513,863. Deductions for taxes, depreciation of plant, and exhaustion of mine, totalling $369,712, leave a profit of $144,151. During September the tonnage handled was over 1,000 tons daily, yielding approximately $7 per ton. A large ore-body found on the 7th level yielding high-grade ore has been proved by diamond-drilling to extend downwards for at least 150 ft., but owing to its irregular shape its extent at depth is yet uncertain.

Work has been resumed at the Davidson with George E. Bent as manager. High-grade ore has been encountered in driving on the 600 ft. level. Diamond-drilling is in progress to prove the main ore-body at depth before proceeding with shaft-sinking and the erection of a mill. At the McIntyre some difficulties have been experienced in the treatment of the ore from the lower workings owing to the occurrence of carbon in the ore. Various experiments have been tried, and it is now believed that a process of oil flotation can be successfully adopted. The Premier-Paymaster is now in operation. The occurrence of a large ore-body has been proved, which has been opened up on the 200 ft. level. The shaft will be put down further. The Beaumont will explore the property at depth by diamond-drilling before attempting further extensive development.

KIRKLAND LAKE.—The output of the four producing mines of this camp amounts approximately to $5,000 daily, which is likely to be largely increased next year when additional mills will be working. The Lake Shore during September produced $40,928 from the treatment of 1,622 tons of ore, the average extraction being $25·23 per ton. A dividend of 2%, the third disbursement during the present year, has been declared. The Teck-Hughes is developing the rich ore-body occurring on its fourth level, the downward continuation of which has been established. Development work towards this body is being pushed on the lower levels. An electrically driven mining plant is being put in operation on the Sylvanite for sinking a new three-compartment shaft. At the Bidgood the main shaft is being put down to the 400 ft. level to open up at that depth the ore-bodies developed on the 300 ft. level. The Kirkland Lake mine is treating upwards of 4,000 tons per month, and development on the 900 ft. level has placed a quantity of high-grade ore in sight. The Granby-Kirkland is showing up well under development, 14 veins having been found, one of them about 6 ft. wide carrying good gold content. The shareholders of the Montreal-Kirkland have decided to resume operations and authorized the sale of 75,000 shares of treasury stock to raise the necessary funds.

LARDER LAKE.—The past few weeks have witnessed a great increase of activity in this district. Hundreds of claims, which had been abandoned after the boom of twelve years ago subsided, have been restaked, and prospectors are now eagerly searching any small areas which may have been overlooked. The Costello vein, a strong body of highly silicified basalt, varying from 15 to 60 ft. wide, which has a known length of 1 mile and is stated to carry gold in commercial quantities, extends over several properties, and is being opened up by the Canadian Associated Goldfields and the Crown Reserve. The Coniagas, of Cobalt, has entered the field, and taken over 300 acres on option.

COBALT.—The Nipissing during September mined ore of an estimated net value of \$197,536, and shipped bullion from Nipissing and custom ore of an estimated net value of \$164,405. The new vein found in August has been driven on, and a section of 60 ft., 3 in. wide, contains ore averaging 2,500 oz. to the ton. During the first nine months of the year the company produced approximately 2,022,000 oz. of silver, which is 15% less than the output of last year for a corresponding period. The decrease in value is about a million dollars.

The gross earnings of the Bailey custom mill in October were \$14,363 from the treatment of 4,787 tons of ore. The shaft of the Victory is being sunk from the 300 ft. level to a depth of 500 ft. A cobalt vein showing some silver, 2 to 5 ft. in width, has been encountered at the 185 ft. level, which is to be tapped at the 500 ft. level. The Right of Way Co. has been declared insolvent and is being wound up. The Peterson Lake has adopted a new scheme of financing by the issue of silver certificates bearing 10% interest and redeemable in two years. The company pledges its silver reserves as security for the payment of the certificates when due. It is hoped to raise \$100,000 in this way. The shaft on the Waldman property of the Oxford-Cobalt is down 70 ft., at which point the vein is reported to be strong, carrying considerable cobalt. The annual statement of the Hudson Bay for the year ended August 31 shows a loss of \$20,347. Work on the Chambers-Ferland mine has been suspended.

WEST SHINING TREE.—There has latterly been some renewal of activity in this area, which is attracting a good deal of attention as a field for investment. The Hollinger Consolidated, of Porcupine, has taken over thirteen claims on Granite Lake on option, and will make a test of the property by diamond drilling. A quartz vein 14 ft. wide runs across the group. An English syndicate has purchased outright the Kingston property, comprising 120 acres, at a price stated to be the largest ever paid for any property in the district. The Atlas will shortly be reopened and the shaft put down to a depth of 360 ft., the necessary funds having been secured by a sale of treasury stock. At the White Rock a vein has been stripped for 600 ft., and a shaft put down. On driving at the 65 ft. level the vein was found to have widened from 2 to 6 ft. and to carry ore averaging \$12 per ton.

VANCOUVER, B.C.

November 11.

THE BRITANNIA DISASTER.—Heavy rains throughout nearly the whole of the southern part of British Columbia between October 12 and 28 have done an immense amount of damage to property and have completely isolated the cities of Vancouver and Victoria from communication with Eastern Canada. In many places the rainfall for the 16 days was in excess of 10 inches, while on the 28th the fall in some places amounted to 3 inches. Disaster fell with a particularly heavy hand at Britannia Beach on the night of October 28, when at half-past nine part of the Britannia Mining & Smelting Company's water-impounding system collapsed, and a roaring torrent of water swept down the mountain and through the settlement, carrying houses, trees, and everything in its path into Howe Sound, and leaving a tangled mass of ruin in its wake. Men, women, and children to the number of not less than forty were either crushed by the falling timbers of their homes or carried into the Sound to be drowned. For several days before the catastrophe the company had kept a constant patrol on the banks of the creek, to see that everything was kept clear, but it appears that the continuous rains had caused landslides in the higher reaches of the creek, and these must have formed an immense dam at some point, which suddenly gave way, and the torrent of water brought down an enormous quantity of debris, breaking down some of the dams and forcing the water out of others. Both of the men that were patrolling the creek at the time were drowned, evidently in an effort to warn their fellow workmen and their families in the settlement below. The first rush of water put the electric-lighting plant out of

commission, and the darkness added to the confusion.

This is the third serious calamity that has befallen the Britannia Mining & Smelting Company and its employees within the last seven years. In the spring of 1915 an avalanche of snow and earth slid down the mountain side, demolished the boarding-house and eight other buildings, collapsed the aerial tramway, and killed 54 men who were in the boarding-house at the time. Last February fire destroyed the 2,500 ton mill, which was the largest mill and the first flotation plant to be erected in the Province.

On the day before the catastrophe Britannia Beach was rejoicing over the rescue of two miners, who had been trapped by a cave in the 3,100 level, and who had been rescued by the indomitable pluck and energy of their fellow workmen, after continuous hard work in relays for eight days, without taking time to support dangerous ground. The rescued miners, who had been without food all this time, were able to walk out of the mine, and, after a meal and a night's sleep, were little the worse for their harrowing experience.

Cariboo.—What promises to be an important new placer-gold discovery has been made recently at Cedar Creek, Quesnel Lake, in the Cariboo district. The original discoverers have cleaned up a considerable quantity of gold by rocking, and the whole creek has been staked in bench claims. Unfortunately the wet weather set in before the extent of the pay-streak could be determined, none but the original discoverers succeeding in reaching bedrock.

A. Sanders, who has been prospecting for the mother-lode of the Cariboo placers for the last three seasons, has made a promising discovery on Proserpine mountain, near Barkerville, consisting of a 30 ft. belt, which on the surface is composed of oxide of iron intercalated with numerous quartz veinlets. At fairly shallow depths the oxide turns into sulphide. The gold seems to be contained in the oxide, rather than the quartz. Assays of the oxide, which always gives a long tail on panning, have ranged between $380 and $450 per ton. It is likely, of course, that there has been a surface concentration, and it is improbable that these values will be found in the sulphide ore. A trial shipment is being taken out, but, with the present condition of the roads, it will be some time before it can be sent to the smelter.

Sheep Creek.—There has been a marked revival of gold mining in the Sheep Creek district, some 35 miles from Nelson. The Nugget Gold Mines, Ltd., which is operating the Nugget and Mother Lode groups, restarted early in the season, and, despite a stop of some six weeks on account of a shortage of water, has produced $60,000 worth of gold up to date this year. There are seven veins on the property, but only two, the Nugget and the Mother Lode, have been developed to any extent. These veins have been developed to a depth of 1,000 ft., and the company is about to start another tunnel, which will cut the veins at 1,500 feet. The mine is equipped with a ten-stamp mill, pebble mill, and cyanide plant. No gold is recovered by amalgamation. The plant is operated by water power obtained from Sheep Creek, which generally fails for a month or six weeks during the heart of the summer.

Oil Activities.—The California oil companies appear suddenly to have realized that, with the price of coal still ranging from $12 to $13 per ton in Victoria and Vancouver, and with the considerable shipping business that takes place from these ports, there is a big opportunity for the sale of oil. Recently the Union Oil Co. bonded the British Columbia Refineries property on Burrard Inlet, and purchased the old Kirkpatrick shingle mill, which is to be converted into a distributing station. In all probability a modern refinery will be built on the British Columbia Refineries' property. Directors of the Shell Oil Co. were in Victoria last week, negotiating for a site on the old Songhees Indian reserve, near the city. The Canadian Pacific company's new ocean liners, which are to be put into commission next year, are oil-burners, and those already in use are to be converted into oil-burners; the Canadian Pacific Railway's coastal boats also are being converted into oil-burners; add to this the industrial and domestic demand, which is ever growing, and it will be seen that it is likely that there will be a good market for oil in the coast cities of British Columbia.

The exploration for oil in the Canadian North-west has been disappointing. Nothing new has been found at Fort Norman, and the original discovery well has not yet been developed into a commercial producer. The Imperial Oil Company, undaunted by failure to date, is not only continuing the explorations in the province of Alberta, and in the North-west Territories, but has started geological reconnaissances in British Columbia,

and if these give promising results the ground will be tested by drills next year.

Probably one of the most favourable indications that the Imperial company has met up to now has been at Pouce Coupé. There the company has been sinking since the middle of the summer, and at a depth of some 1,800 ft. struck a strong flow of "wet" gas, estimated at about two million cubic feet per day. Drilling was stopped and the boiler was moved back, as it was feared that the fire might ignite the gas. After this had been done the drill was re-started, and had been in operation only 15 minutes when a still stronger flow of gas, estimated at eight million cubic feet per day, was struck. This gas is still blowing off as vigorously as when first struck, and it is so "wet" that it has the appearance of steam coming from the 21 in. bore. It is proposed to cap this gas, and use it as fuel for drilling a number of other holes. Pouce Coupé is situated far more conveniently as regards transport than many of the other places where the company has been exploring. It is on the Pouce Coupé River, a tributary of the Peace River, and is only about 75 miles from a branch line of the Canadian National railway system, and already a survey has been made to connect Pouce Coupé with that system.

A large number of oil claims have been staked near Terrace and Burns Lake, both on the Grand Trunk Pacific railway, and both places are to be tested by one or two drills next year. Companies have been organized and the drilling outfits purchased for this work. The Provincial Government has sunk two or three bores in the vicinity of Hudson's Hope, in the Peace River district, but has obtained no results.

PERSONAL

Clyde Allan left last month for Nigeria.

Ernest Bottoms has left for Nigeria.

George Bottoms is expected from Nigeria.

Vicars W. Boyle has returned to Nigeria.

Sir John Cadman has been appointed chief technical adviser to the Anglo-Persian Oil Company. He is now in the United States.

G. W. Campion is here from West Africa.

A. B. Climas has left for the Ervedosa tin mines, Portugal.

A. W. Cooke is back from Alaska.

W. H. Cusworth has been appointed works manager for Hadfields (Australia), Ltd., Sydney.

Dr. J. R. Falconer is returning to Nigeria next month.

R. J. Frecheville has moved his office from Salisbury House to 5, London Wall Buildings.

O. T. Gorton has returned to Portugal.

W. J. Humphreys has left for Prestea, West Africa.

H. F. Hutson is expected from Nigeria.

C. F. Jobling has left for West Africa.

S. J. Lett has left for Rhodesia and Zambesia.

W. J. Loring was elected for a second year as president of the American Mining Congress.

Ross Macartney is here from Rhodesia.

B. Hope Nicolson has left for Nigeria.

F. Douglas Osborne has been elected chairman of the Gopeng, Tekka, and other Malayan tin mining companies, in succession to the late James Wickett.

R. W. Palmer, of the Geological Survey of India, has been appointed lecturer in geology in the Manchester University.

W. Pellew-Harvey has returned from Australia by way of Canada.

J. H. Rich is returning to Tronoh.

William Russell, of the Dorr Co., is on a visit to South Africa, and is not expected to return before February.

R. R. Simpson has been appointed Chief Inspector of Mines in India.

Dr. L. Dudley Stamp has resigned as demonstrator in geology at King's College, London, and is leaving for Burma to undertake geological advisory work.

Dr. F. L. Stillwell has resigned as geologist to the Bendigo Amalgamated Goldfields, Ltd., and is now intending to visit South Africa, North America, and London.

Ralph S. G. Stokes has sailed for South Africa.

E. O. Teale is expected from Tanganyika Territory.

R. Arthur Thomas has been on a professional visit to Upper Silesia.

A. Beeby Thompson has gone to Burma for the Anglo-Burma Oil Company.

W. E. Thorne has returned from Nigeria, and has gone to California.

George H. Thurston is back from India.

E. R. Weidlein has been appointed director of the Mellon Institute of Industrial Research, Pittsburgh.

R. B. Wham has returned from Nigeria.

Alpheus F. Williams is here from South Africa and is going to the United States.

W. R. Wolton has left the Poderosa company, and has joined the staff of the Corocoro copper mines, Bolivia.

Arthur Blackman, a London solicitor, well-known for his excellent work in connexion with mining companies, died on December 3, after a long illness.

F. E. Armstrong, professor of mining in the University of Sheffield, died on October 28 at the early age of 42. He had extensive experience in coal-mining in this country, and also in Mexico and British Columbia. Not qualifying for war service, he volunteered for ambulance duty at the front, and remained in France for three years. Subsequently he returned to take control of the labour section of the Coal Mines Department of the Board of Trade.

E. Windsor Richards died on November 12 at the age of 90. In early days he was connected with the Tredegar Iron Works, and later became chief engineer at the Ebbw Vale Steel Works. From 1876 onwards he was general manager and subsequently chairman of directors of Bolckow,

Vaughan & Co., of Middlesbrough. His chief service to metallurgy was the development of the Gilchrist-Thomas basic bessemer process. He was a past-president of the Iron and Steel Institute and the Institution of Mechanical Engineers.

HENRY WILSON FOX died in London last month, aged 58. He was educated at Cambridge and was called to the bar by Lincoln's Inn. Subsequently he went to Johannesburg as a member of the staff of the Consolidated Gold Fields. He assisted John Hays Hammond in framing the Rhodesian mining laws, and among other and various activities he was editor of the *South African Mining Journal* and public prosecutor for Rhodesia. He returned to England in 1897 and was later appointed manager for the British South Africa Company, with which he had ever since been connected.

TRADE PARAGRAPHS

THE WESTINGHOUSE ELECTRIC INTERNATIONAL Co., of New York and London, send us their monthly magazine for December, and also circulars relating to the wide applications of electricity.

THE WESTINGHOUSE ELECTRIC & MANUFACTURING Co., of East Pittsburgh, U.S.A., send us their Christmas number of *Contact*, a paper giving the popular side of the firms' many manufactures.

VANADIUM, LTD., of 64, Victoria Street, Westminster, agents in this country for the Vanadium Corporation of America, have issued an illustrated booklet giving particulars of the corporation's mining and dressing plant in Peru.

BELLS' UNITED ASBESTOS CO., LTD., of Southwark Street, London, S.E. 1, send us their new catalogue relating to their Poilite sheets and tiles. Poilite is made of asbestos and portland cement, and is extensively used in building construction where freedom from fire risks is desirable.

BOVING & CO., LTD., of 56, Kingsway, London, W.C. 2, announce that they have a complete new set of lantern slides showing examples of modern water-turbines and hydro-electric installations suitable for lecture purposes. These slides are available for lending to institutes, technical schools, etc.

EDGAR ALLEN & CO., LTD., of the Imperial Steel Works, Sheffield, send us a copy of the *Edgar Allen News* for December. This contains articles on modern electric furnaces for heat treatment, and steel castings for cement-making machinery, and on certain points in connexion with the care and treatment of drill steels.

A double-acting two-stage air-compressor made by the ATLAS-DIESEL COMPANY, of Stockholm (London office: 35, Surrey Street, Strand), is described and illustrated in *Engineering* for November 11. This is said to be the largest air-compressor ever made in Sweden. It was built for one of the iron-mining companies in Swedish Lapland.

DANIEL ADAMSON & CO., LTD., of Dukinfield, near Manchester, send us their new catalogue entitled "Cheap Power for Every Need." This gives details of steam turbines, turbo-blowers, turbo-pumps, turbo-generator sets, condensing plant, Lancashire and Cornish boilers and boiler-house plant, piping installations, chimneys, boiler setting, and everything for traction, lighting, and industrial supply.

HOLMAN BROTHERS, LTD., of Camborne, have won a notable success with their "C.H.2" cradle hammer drill at the Van Ryn Deep. The results are believed to constitute a world's stoping record. The following are the details: Period, September 2 to October 1, 1921; number of machines, 3; working shifts, 26; machine shifts, 78; total fathoms broken, 248; fathoms per machine shift, 3·18; stope width 69 inches.

H. R. MARSDEN, LTD., of Leeds, were well represented at the Public Works, Roads, and Transport Exhibition held last month at the Agricultural Hall, Islington, specializing in their breakers intended for producing stone suitable for roads. Their Blake-Marsden "X" type is a breaker intended for heavy duty; its design is simple, the construction strong, the adjustment easy, and it is economical of power. The jaws are in two equal pairs, instantly reversible top to bottom respectively, thus ensuring maximum working life; the main bearings are away from the dust, the working parts are accurately machined, and the frame is strengthened by ribs extending round both sides and front. The Blake-Marsden "Y" type is an eccentric-motion machine, and is designed to combine strength, simplicity, and efficiency. The jaws are arranged as in the "X" type. The pitman has special arrangements for lubrication; the renewal of working parts is simple; and strengthening ribs extend all round the frame.

METAL MARKETS

COPPER.—The standard copper market in London was steady during November, such price movements as took place being comparatively small. Though sentiment became slightly more optimistic on the good American advices, little encouragement was offered by the aspect of the position in this country, where consuming demand continued unsatisfactory. As already indicated, the market here was dominated by the firmness in the United States, where the cent price of electrolytic rose from 13 cents to 13¾ cents during the month. The American revival is undoubtedly genuine; domestic demand has broadened substantially, and this, coupled with quite a good export business, is responsible for the appreciable increase recently recorded in sales. That sentiment has taken a decidedly good turn in America is shown by the fact that rumours have been current that some of the mines now closed might shortly reopen. It appears unlikely, however, that such mines will resume operations before the spring or summer of next year. Producers in the United States, meanwhile, have gained control of the market there, and values are likely to be steady, if not firm, in the near future. It might have been expected that values of standard would advance in sympathy with New York, but any possibility of a substantial rise here was scotched by the firmer tendency of the sterling exchange. An event of note during the month was the liquidation of the whole of the British Government stocks of copper, amounting to some 9,000 tons.

Average price of cash standard copper: November, 1921, £66 13s. 6d.; October, 1921; £67 8s. 1d.; November, 1920, £84 18s. 6d.; October, 1920, £93 10s. 1d.

TIN.—The tendency in the standard tin market in London during the past month was distinctly towards higher levels, and on balance values closed at a substantial advance. Various factors assisted

DAILY LONDON METAL PRICES: OFFICIAL CLOSING
Copper, Lead, Zinc, and Tin per Long Ton

COPPER

	Standard Cash	Standard (3 mos.)	Electrolytic	Wire Bars	Best Selected
Nov.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.
10	[illegible] to 66 7 6	67 0 0 to 67 2 6	74 0 0 to 76 0 0	75 0 0 to 76 0 0	— —
11	66 10 [illegible] to [illegible] 12 6	67 5 0 to 67 7 6	74 0 0 to 76 0 0	75 0 0 to 76 0 0	67 10 0 to 69 10 0
14	[illegible] 0 to [illegible] 6	67 15 0 to 67 17 6	75 0 0 to 77 0 0	76 0 0 to 77 0 0	—
15	[illegible] to 66 17 6	67 12 6 to 67 15 0	75 0 0 to 77 0 0	76 0 0 to 77 0 0	68 0 0 to 70 0 0
16	[illegible]	67 12 6 to 67 15 0	75 0 0 to 77 0 0	76 0 0 to 77 0 0	— —
17	[illegible] 0 to [illegible] 2 6	67 0 0 to 67 2 6	74 10 0 to 76 10 0	75 10 0 to 76 10 0	— —
18	[illegible] 0 to 66 12 6	67 7 6 to 67 10 0	74 10 0 to 76 10 0	75 10 0 to 76 10 0	67 0 0 to 69 0 0
21	[illegible] to 66 10 [illegible]	67 7 6 to 67 10 0	74 10 0 to 76 10 0	75 10 0 to 76 10 0	— —
22	66 12 [illegible] to 66 15 [illegible]	67 12 6 to 67 15 0	74 10 0 to 76 10 0	75 10 0 to 76 10 0	67 0 0 to 69 0 0
23	[illegible] to 66 17 6	67 12 6 to 67 15 0	75 0 0 to 76 10 0	76 0 0 to 76 10 0	— —
24	[illegible]	67 15 0 to 67 17 6	75 10 0 to 77 0 0	76 10 0 to 77 0 0	— —
25	66 15 [illegible] to [illegible] 17 6	67 15 0 to 67 17 6	75 10 0 to 77 0 0	76 10 0 to 77 0 0	67 19 0 to 69 10 0
28	[illegible] 7 6 to 67 10 [illegible]	68 7 6 to 68 10 0	75 10 0 to 77 0 0	76 10 0 to 77 0 0	— —
29	67 10 0 to 67 12 6	68 10 0 to 68 12 6	75 10 0 to 77 10 0	76 10 0 to 77 10 0	68 10 0 to 70 10 0
30	67 0 [illegible] to 67 2 6	68 0 0 to 68 2 6	75 10 0 to 77 10 0	76 10 0 to 77 10 0	— —
Dec.					
1	67 2 6 to 67 5 0	68 0 0 to 68 2 6	75 10 0 to 77 10 0	76 10 0 to 77 10 0	to
2	67 0 0 to 67 2 6	67 17 6 to 68 0 0	75 0 0 to 77 0 0	76 0 0 to 77 0 0	68 0 0 to 70 0 0
5	67 2 6 to 67 5 0	68 0 0 to 68 2 6	75 0 0 to 77 0 0	76 0 0 to 77 0 0	to
6	67 5 0 to 67 7 6	68 2 6 to 68 5 0	75 0 0 to 77 0 0	76 0 0 to 77 0 0	68 0 0 to 70 0 0
7	67 7 6 to 67 10 0	68 5 0 to 68 7 6	75 0 0 to 76 10 0	75 10 0 to 76 10 0	to
8	67 2 6 to 67 5 0	68 2 6 to 68 5 0	75 0 0 to 76 10 0	75 10 0 to 76 10 0	— to
9	66 15 0 to 66 17 6	67 15 0 to 67 17 6	75 0 0 to 76 10 0	75 10 0 to 76 10 0	67 10 0 to 69 10 0

to bring about the better tone. It had been felt for some time past that the price of tin in London was decidedly low, and that whatever adverse elements the situation might contain were sufficiently discounted in the depressed quotation. With this state of opinion prevalent, the bad statistical position was practically ignored, while confidence was evident in an early establishment of something approaching equilibrium between supply and demand. This optimism was duly justified, for the statistics published at the beginning of December revealed an appreciable decrease in visible supplies during the month under review. Meanwhile, demand from British tinplate works continued fairly satisfactory, and towards the end of the month America came in as a buyer on a good scale despite the fact that the sterling exchange was moving unfavourably for the United States. This would indicate the extent of the present revival in the American tinplate trade. There was a fair Continental demand during the month. Sales in the Straits were on a good scale during the first two weeks or so, but later—as is so often the case when the London market looks like being in for a substantial rise—sellers there became more reserved. Batavia and China sold practically nothing during the month.

Average price of cash standard tin: November, 1921, £159 0s. 2d.; October, 1921, £156 10s. 4d.; November, 1920, £241 5s. 6d.; October, 1920, £258 8s. 8d.

LEAD.—The London lead market was consistently firm during the month. Holders appeared to have the situation well under control, and with arrivals of fresh metal restricted, values naturally had a hardening tendency. There was a diminution rather than an increase in the volume of English consuming demand, but a fairly keen inquiry from the Continent resulted at times in a very active business on 'Change. At the present time there is little doubt that Europe generally is suffering from a shortage of supplies, and Germany—herself a producer—is buying largely. There is very little Spanish metal arriving at British ports, the bulk of current shipments going to the Continent; and although some American lead has been coming in, the quantities involved have been insufficient to turn the scale. Prospects of any increase in arrivals in the near future are poor; for, although it is understood that metal is afloat from Australia, Burma, and Africa, the amount involved is not very large. There is little doubt that so far as the English consuming trades are concerned, lower prices are a necessity; and from this point of view every rise in the price is to be regretted.

Average price of soft pig lead: November, 1921, £24 4s. 10d.; October, 1921, £23 10s. 8d.; November, 1920, £32 5s. 6d.; October, 1920, £35 2s. 1d.

SPELTER.—Sentiment on the London spelter market was rather changeable during November. The tendency of values at the beginning of the month was somewhat easy, owing to fears of larger shipments from Silesia on the transfer of the spelter mines and works there from Germany to Poland, while, furthermore, the fact that arrivals during October were comparatively heavy was not without its influence. During the middle of the month, however, a steadier tone was evident, while, later, sentiment became more optimistic and values rose, a small advance on the month being registered. On the whole, the situation during the month under review experienced a little improvement. Demand from English galvanizers continued fairly satisfactory, and although there was perhaps no actual shortage of supplies, holders at no time displayed much eagerness to offer. As a matter of fact, stocks in the United Kingdom are still dwindling, which is a good indication of the present ratio of demand and supply. As has been the case for some time past, Continental producers offered very little, and it is fairly obvious that consumers there are absorbing the bulk of the output. It is worthy of note that the Belgian output is slowly broadening. Nothing materialized during the month from the scheme to resume operations at the English smelters, but it is possible that a restart may be made in the

PRICES ON THE LONDON METAL EXCHANGE.
Silver per Standard Ounce; Gold per Fine Ounce.

Lead: Soft Foreign	Lead: English	Zinc (Spelter)	Standard Tin: Cash	Standard Tin: 3 mos.	Silver: Cash	Silver: Forward	Gold	
£ s. d. £ s. d.	£ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	d.	d.	s. d.	Nov.
24 0 0 to 23 12 6	25 0 0	25 7 6 to 26 5 0	156 7 6 to 156 10 0	158 12 6 to 158 15 0	39	38¾	104 2	10
24 2 6 to 23 15 0	25 0 0	25 12 6 to 26 10 0	158 0 0 to 158 5 0	160 0 0 to 160 5 0	38½	38	104 6	11
24 2 6 to 23 15 0	25 0 0	25 15 0 to 26 12 6	157 12 6 to 157 15 0	159 12 6 to 159 15 0	38½	37⅞	104 5	14
24 7 6 to 23 17 6	25 5 0	25 17 6 to 26 12 6	157 7 0 to 157 10 0	159 7 6 to 159 10 0	38⅜	37⅞	103 9	15
24 7 6 to 23 17 6	25 5 0	25 17 6 to 26 12 6	157 15 0 to 158 0 0	159 15 0 to 160 0 0	38½	37⅞	103 6	16
24 5 0 to 23 15 0	25 5 0	25 17 6 to 26 10 0	159 5 0 to 159 10 0	161 5 0 to 161 10 0	38¾	38¼	102 8	17
24 5 0 to 23 15 0	25 5 0	25 17 6 to 26 10 0	158 15 0 to 159 0 0	160 15 0 to 161 0 0	39	38½	103 0	18
24 10 0 to 24 0 0	25 10 0	25 15 0 to 26 7 6	160 12 6 to 160 15 0	162 10 0 to 162 15 0	39¼	38¾	102 11	21
24 15 0 to 24 5 0	25 15 0	25 17 6 to 26 10 0	161 10 0 to 161 15 0	163 5 0 to 163 10 0	38	37¾	103 3	22
25 5 0 to 24 12 6	26 5 0	26 17 6 to 26 10 0	160 10 0 to 160 15 0	162 5 0 to 162 10 0	38½	38¼	102 11	23
25 2 6 to 24 10 0	26 5 0	26 5 0 to 26 15 0	160 10 0 to 160 15 0	162 10 0 to 162 15 0	38¼	37⅞	102 11	24
25 10 6 to 24 15 0	26 15 0	26 5 0 to 26 15 0	161 10 0 to 161 15 0	163 10 0 to 163 15 0	37⅝	37⅜	102 11	25
25 17 0 to 25 5 0	27 0 0	26 7 6 to 26 17 6	163 10 0 to 163 12 6	165 5 6 to 165 10 0	37¼	37⅛	103 0	28
26 0 0 to 25 5 0	27 0 0	26 7 6 to 26 15 0	163 5 0 to 163 10 0	165 0 0 to 165 5 0	37⅝	37⅜	103 2	29
26 0 0 to 25 5 0	27 0 0	26 7 6 to 26 17 6	162 10 0 to 162 15 0	164 10 0 to 164 15 0	37½	37½	102 11	30
								Dec.
26 0 0 to 25 5 0	27 0 0	26 10 0 to 27 0 0	163 5 0 to 163 7 6	165 2 6 to 165 7 6	37¾	37½	102 7	1
25 5 0 to 24 12 6	26 10 0	26 5 0 to 26 15 0	164 12 6 to 164 17 6	166 5 0 to 166 10 0	37½	37¼	101 3	2
25 7 6 to 24 10 0	26 10 0	26 5 0 to 26 15 0	167 0 0 to 167 2 6	168 15 0 to 168 17 6	36½	36½	101 8	5
25 7 6 to 24 12 6	26 10 0	26 2 6 to 26 15 0	167 17 6 to 168 0 0	169 10 0 to 169 12 6	36½	36¼	101 2	6
25 12 6 to 24 15 0	26 15 0	26 5 0 to 26 17 6	167 5 0 to 167 10 0	169 0 0 to 169 5 0	36¼	36	100 6	7
25 10 0 to 24 15 0	26 15 0	26 7 6 to 26 17 6	166 0 0 to 166 5 0	168 0 0 to 168 5 0	34½	34½	100 11	8
25 10 0 to 24 15 0	26 15 0	26 10 0 to 26 17 6	168 2 6 to 168 5 0	169 15 0 to 170 0 0	34¾	34¼	100 3	9

near future. Meanwhile, the big Risdon plant in Australasia has commenced production. The market in America was firm during the first part of the month, but later on fell away somewhat. In view of the advance in sterling, this brings the possibility of American offerings to this country appreciably nearer.

Average price of spelter: November, 1921, £26 4s. 10d.; October, 1921, £26 10s. 7d.; November, 1920, £35 14s. 7d.; October, 1920, £40 5s. 6d.

ZINC DUST.—Prices are steady; Australian high-grade £50, American 92 to 94% £47 10s., and English 92 to 94% £45 per ton.

ANTIMONY.—Quotations are a little easier as follows: English regulus ordinary brands £34 to £37, special brands £35 5s. to £39, and 98 to 99% £25 to £28. Foreign material is quiet at £22 to £24 10s. for spot.

ARSENIC.—The price of Cornish white, 99%, is well maintained at £42 10s., delivered London. Foreign material is cheaper.

BISMUTH.—Holders continue to quote 7s. 6d. per lb.

CADMIUM.—Business is a little better at the unchanged price of 6s. per lb.

ALUMINIUM.—Home producers still ask £120 for home and £125 for export business; foreign metal can be had at £95 f.o.b. Continent.

NICKEL.—Domestic makers ask £185 for both home and export business; foreign material, however, is offering at about £175.

COBALT METAL.—The market is quiet, with the price at 14s. per lb.

COBALT OXIDE.—Values are unaltered at 10s. 9d. for black oxide and 12s. per lb. for grey.

PLATINUM AND PALLADIUM.—The market is steady; manufactured platinum £19 10s. per oz., raw £18; manufactured palladium £19 10s., raw £13 to £14.

QUICKSILVER.—Towards the end of November the leading interests advanced their price. The present quotation for second-hand material is about £10 7s. 6d. per bottle.

SELENIUM.—The price of powder is 9s. 6d. per lb.

TELLURIUM.—Sellers quote 70s. to 80s. per lb.

SULPHATE OF COPPER.—The price is easier at £27 to £28 for both home and export business.

MANGANESE ORE.—Business is quiet, the quotation being 1s. 2d. per unit c.i.f.

TUNGSTEN ORE.—A weak market at around 12s. c.i.f. for 65% WO_3.

MOLYBDENITE.—Values have weakened and sellers of 85% would now accept 30s. to 32s. 6d. c.i.f.

CHROME ORES.—Business is quiet and the quotation nominal at £4 to £4 5s. c.i.f.

SILVER.—The price of spot bars on November 1 was 40½d. Some support from China was seen, and the quotation rose to 40¼d. on the 2nd. Subsequently the price fluctuated within narrow limits, falling to 38¼d. on the 12th. A rise then took place, and on the 19th and 21st 39¼d. was quoted. By the 26th, however, the price was down again to 37⅝d., owing to absence of support. On the 30th the closing quotation was 37½d.

GRAPHITE.—Sellers now ask £20 to £23 c.i.f. for Madagascar 80 to 90%. Business is quiet.

IRON AND STEEL.—It was expected that further reductions in pig iron quotations would be delayed until next month, so that when it was announced at the end of November that pig iron would be cheaper, a certain amount of surprise was evident. No. 3 Cleveland G.M.B. is now £5 a ton, representing a fall from £11 5s. at the beginning of the year. Business, however, has been slow, and it remains to be seen whether buyers will be sufficiently attracted to place substantial orders. Hematite has been weak owing to the competition among makers to find buyers of their products as they are made, rather than have to put iron into stock. Italy has bought a little, while South Wales has also been a purchaser. East Coast mixed numbers are flat at 107s. 6d. to 110s. As regards finished material, a little more business has been coming in, but works are still only partly employed. Continental business is waning, owing to increasing difficulties in procuring supplies, except for far forward dates, from that side.

STATISTICS

Production of Gold in the Transvaal.

	Rand	Elsewhere	Total	Price of
	Oz.	Oz.	Oz.	Gold per oz.
				s. d.
October 1920	645,819	[illegible]	[illegible]	117 6
November	618,525	15,212	[illegible]	117 6
December	617,549	[illegible]	[illegible]	115 0
Total, 1920	[illegible]	204,587	8,153,625	
January, 1921	[illegible]	14,168	651,593	1[illegible] 0
February	[illegible]	14,370	588,137	103 9
March	[illegible]	14,551	671,123	103 9
April	[illegible]	16,073	681,982	1[illegible] 9
May	[illegible]	16,026	687,776	103 9
June	[illegible]	15,1[illegible]7	678,490	107 6
July	[illegible]	16,080	689,555	112 6
August	[illegible]	16,296	711,526	111 6
September	[illegible]	16,939	[illegible]	11[illegible] [illegible]
October	[illegible]	17,477	707,825	103 0

Natives Employed in the Transvaal Mines.

	Gold mines	Coal mines	Diamond mines	Total
October 31, 1920	159,426	13,858	4,214	177,498
November 30	158,773	14,245	3,504	176,522
December 31	159,671	14,263	3,340	177,274
January 31, 1921	165,287	14,541	3,319	183,147
February 28	171,518	14,697	1,612	187,827
March 31	17[illegible]	14,[illegible]	1,364	190,634
April 30	172,826	14,908	1,316	189,050
May 31	170,595	14,510	1,302	186,407
June 30	168,152	14,704	1,317	184,173
July 31	16[illegible]	14,688	1,246	18[illegible]
August 31	169,[illegible]	14,446	1,207	184,661
September 30	171,912	14,244	1,219	187,375
October 31	175,331	13,936	1,223	190,490

Cost and Profit on the Rand.

Compiled from official statistics published by the Transvaal Chamber of Mines.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
October, 1920	1,871,140	39 9	26 1	13 8	1,278,385
November	1,799,710	40 2	26 3	13 1	1,255,749
December	1,797,970	39 11	26 8	13 3	1,193,672
January, 1921	1,895,235	35 0	26 3	8 9	829,436
February	1,575,320	35 6	28 6	7 0	550,974
March	1,958,730	34 5	26 1	8 4	813,636
April	1,9[illegible]	34 5	25 10	8 7	854,533
May	1,955,357	35 3	26 2	9 1	889,520
June	1,[illegible],[illegible]49	35 10	25 10	10 0	979,769
July	2,010,236	37 2	25 7	11 7	1,163,565
August	2,050,722	37 3	25 4	11 11	1,226,282
September	1,997,086	36 8	25 2	11 6	1,151,127

Production of Gold in Rhodesia.

	1919	1920	1921
	£	oz.	oz.
January	211,917	43,428	4[illegible]
February	220,885	44,237	40,816
March	225,808	45,779	31,995
April	213,160	47,000	47,858
May	218,057	46,266	48,744
June	214,215	45,054	49,466
July	214,919	46,208	51,564
August	207,339	48,740	53,200
September	223,719	[illegible]471	52,436
October	204,184	47,343	53,424
November	186,462	46,782	—
December	158,835	46,190	—
Total	2,499,498	552,498	482,459

Transvaal Gold Outputs.

	September		October	
	Treated Tons	Yield Oz.	Treated Tons	Yield Oz.
Aurora West	10,800	£15,145†	10,130	£13,87[illegible]*
Brakpan	57,500	22,113	58,000	22,435
City Deep	89,000	35,729	90,600	37,[illegible]97
Cons. Langlaagte	44,000	£7[illegible]†	45,100	£[illegible]*
Cons. Main Reef	50,000	17,719	50,000	17,[illegible]
Crown Mines	193,000	58,984	198,000	59,831
D'rb'n Roodepoort Deep	24,350	9,502	27,000	9,[illegible]
East Rand P. M.	124,000	33,652	127,000	33,270
Ferreira Deep	32,200	10,296	32,500	10,076
Geduld	45,000	16,185	46,500	17,282
Geldenhuis Deep	[illegible]	12,686	47,321	12,591
Glynn's Lydenburg	3,675	£7,162§	4,003	£[illegible]‡
Goch	17,100	£20,280†	17,200	£19,544*
Government G.M. Areas	140,000	£318,760†	140,000	£309,087*
Kleinfontein	49,700	13,017	51,000	13,912
Knight Central	28,600	6,761	28,500	6,572
Langlaagte Estate	41,600	£68,912†	43,600	£69,020*
Luipaard's Vlei	22,200	£27,020†	21,160	£2[illegible]*
Meyer & Charlton	13,200	£42,1[illegible]†	14,500	£43,133*
Modderfontein, New	10[illegible]	46,994	107,000	49,278
Modderfontein B	59,000	3[illegible]	59,000	30,661
Modderfontein Deep	43,000	23,35[illegible]	43,300	21,119
Modderfontein East	25,[illegible]	9,791	27,000	9,724
New Unified	10,900	£13,958†	11,200	£13,488*
Nourse	41,200	15,062	44,500	14,767
Primrose	20,700	£25,715†	21,[illegible]	£23,326*
Randfontein Central	130,000	£202,792†	118,500	£180,830*
Robinson	40,000	7,701	40,200	7,989
Robinson Deep	63,600	18,486	61,300	19,167
Roodepoort United	22,600	£23,188†	20,500	£20,663*
Rose Deep	54,000	13,676	57,700	13,977
Simmer & Jack	55,200	13,298	60,000	13,941
Springs	36,250	16,075	41,400	17,507
Sub Nigel	10,200	5,513	10,200	5,810
Transvaal G.M. Estates.	15,445	£27,998§	16,040	£27,[illegible]‡
Van Ryn	31,630	£50,287†	33,300	£47,[illegible]*
Van Ryn Deep	46,400	£144,960†	53,400	£151,944*
Village Deep	48,100	15,308	53,200	16,759
West Rand Consolidated	32,000	£48,[illegible]	34,100	£46,974*
Witw'tersr'nd (Knights)	40,000	£56,758†	40,500	£52,266*
Witwatersrand Deep	33,630	9,717	33,170	9,785
Wolhuter	32,200	7,939	33,200	8,065

* Gold at £5 3s. per oz. † £5 10s. per oz. ‡ £5 1s. 6d. per oz. § £5 8s. 3d. per oz.

Rhodesian Gold Outputs.

	September.		October	
	Tons	Oz.	Tons	Oz.
Cam & Motor	13,900	£24,501‡	13,000	4,823
Falcon	15,419	2,672*	15,890	2,925‖
Gaika	4,098	1,373	4,181	1,400
Globe & Phœnix	6,013	6,304	6,241	6,061
Jumbo	1,300	504	1,650	505
London & Rhodesian	2,473	£3,054	3,554	£4,135
Lonely Reef	4,950	4,418	5,100	4,610
Planet-Arcturus	5,700	2,611	6,010	2,530
Rezende	5,700	2,607	5,800	2,761
Rhodesia G.M. & I.	270	305	310	316
Shamva	55,300	£42,945‡	56,600	£42,129§
Transvaal & Rhodesian	1,620	£4,981†	—	—

* Also 2[illegible]5 tons copper. † At par. ‖ Also 275 tons copper. § Gold at £5 2s. 6d. per oz. ‡ Gold at £5 5s. per oz.

West African Gold Outputs.

	September		October	
	Tons	Oz.	Tons	Oz.
Abbontiakoon	6,825	£13,395*	7,700	£11,699*
Abosso	6,397	2,596	6,275	2,547
Ashanti Goldfields	7,685	7,263	7,537	7,012
Obbuassi	695	£3,117†	662	£3,720†
Prestea Block A	8,122	£14,594*	7,220	£11,953*
Taquah	3,300	2,097	3,270	2,085

* At par. † Including premium.

West Australian Gold Statistics.—Par Values.

	Reported for Export Oz.	Delivered to Mint Oz.	Total Oz.	Par Value £
February, 1921....	684	26,872	27,556	117,050
March...........	10	47,875	47,885	202,401
April	607	46,602	47,209	200,635
May	474	47,638	51,503	217,495
June............	153	28,194	28,347	120,410
July	1,641	44,917	46,558	197,774
August..........	110	51,731	51,841	220,205
September.......	380	50,728	51,108	217,092
October	1,910	51,286	53,196	225,959
November	156	46,429	46,585	197,879

Australian Gold Outputs.

1921	West Australia	Victoria	Queensland	New South Wales
	oz.	oz.	oz.	£
January .	51,458	4,587	4,582	20,463
February.	27,557	10,940	9,046	21,575
March ...	47,886	12,383	6,690	24,344
April	47,273	5,954	2,591	34,101
May	48,113	10,280	2,077	15,356
June.....	28,347	10,431	1,602	11,640
July	46,558	5,528	1,531	16,416
August...	51,842	8,941	1,413	15,946
September	—	—	—	16,942
October .	—	—	—	—
November	—	—	—	—
December	—	—	—	—
Total ..	349,034	69,047	29,532	176,983

Australasian Gold Outputs.

	September		October	
	Tons	Value £	Tons	Value £
Associated G.M. (W.A.)	5,789	7,512‖	6,176	7,588‖
Blackwater (N.Z.)	3,159	6,372*	3,262	6,549*
Gold'n Horseshoe (W.A)	10,128	5,325‡	10,194	5,376‡
Grt Boulder Pro. (W.A.)	8,312	27,014‖	9,333	32,665‖
Ivanhoe (W.A.)	14,804	6,041‡	15,031	6,030‡
Kalgurli (W.A.)	—	2,207*b*	—	—
Lake View & Star (W.A.)	6,550	12,229†‖	5,339	13,272‖
Mount Boppy (N.S.W.)	—	—	—	—
Oroya Links (W.A.) ..	1,541	7,618†‖	1,415	7,521†‖
South Kalgurli (W.A.)	7,610	13,532‖	7,542	13,954‖
Waihi (N.Z.)..........	4,236	3,540‡ 35,144§	13,560	3,752‡ 19,838§
,, Grand Junc'n (N.Z.)	6,280	1,771‡ 4,321§	5,910	1,494‡ 4,188§
Yuanmi (W.A.)	6,303	18,757**d*	—	—

* Including premium ; † Including royalties ; ‡ Oz. gold ; § Oz. silver ; ‖ At par. *b* Profit. *d* Four months.

Miscellaneous Gold and Silver Outputs.

	September		October	
	Tons	Value £	Tons	Value £
Brit. Plat. & Gold (C'lbia)	—	283*p*	—	106*p*
El Oro (Mexico)	34,250	201,000†	33,250	118,000†
Esperanza (Mexico)	—	438*e*	—	1,584*e*
Frentino & Bolivia (C'lbia)	1,780	7,536*	1,950	8,002*
Keeley Silver (Canada) ..	—	—	—	102,000*s*
Mexico El Oro (Mexico)..	—	—	—	—
Mining Corp. of Canada .	—	148,892*s*	—	—
Oriental Cons. (Korea) ...	19,398	83,775†	—	92,870†
Ouro Preto (Brazil)	6,500	2,375‖	7,100	2,350
Plym'th Cons. (Calif'rnia	8,500	10,082*	8,500	8,600*
St. John del Rey (Brazil).	—	39,500*	—	43,500*
Santa Gertrudis (Mexico)	29,817	17,000‡	29,927	13,161‡
Tomboy (Colorado)	18,000	73,000†	18,000	78,500†

* At par. † U.S. Dollars. ‡ Profit, gold and silver. ‖ Oz. gold. *p* Oz. platinum and gold. *s* Oz. silver. *e* Profit in dollars.

Pato (Colombia): 22 days to November 12, \$10,696 from 128,251 cu. yd.

Nechi (Colombia): 31 days to November 11, \$19,727 from 289,111 cu. yd.

Indian Gold Outputs.

	September		October	
	Tons Treated	Fine Ounces	Tons Treated	Fine Ounces
Balaghat	3,200	2,563	3,300	2,371
Champion Reef	11,650	4,848	11,766	4,869
Mysore...............	17,417	10,531	17,512	10,504
North Anantapur	700	898	500	602
Nundydroog	8,771	5,318	9,011	5,344
Ooregum	12,900	8,484	12,900	8,496

Production of Gold in India.

	1917	1918	1919	1920	1921
	Oz.	Oz.	Oz.	Oz.	Oz.
January	44,718	41,420	38,184	39,073	34,028
February ...	42,566	40,787	36,384	38,872	32,529
March	44,617	41,719	38,317	38,760	32,576
April	43,726	41,504	38,248	37,307	32,363
May.........	42,901	40,889	38,608	38,191	32,656
June	42,924	41,264	38,359	37,864	32,207
July	42,273	40,229	38,549	37,129	32,278
August	42,591	40,496	37,850	37,375	32,498
September ..	43,207	40,088	36,813	35,497	32,642
October	43,041	39,472	37,138	35,023	32,186
November ..	42,915	36,984	39,628	34,522	—
December ..	44,883	40,149	42,643	34,919	—
Total ..	520,362	485,236	461,171	444,532	325,973

Base Metal Outputs.

		Sept.	October
Broken Hill Prop......	Tons lead conc. ...	1,117	1,312
	Tons zinc conc.	4,322	5,798
Broken Hill South	Tons lead conc.	2,949	3,627
Burma Corporation....	Tons refined lead ..	2,534	3,198
	Oz. refined silver ..	294,102	401,300
Mount Lyell	Tons copper	602	610
	Oz. silver	20,152	17,519
	Oz. gold	412	382
North Broken Hill.....	Tons lead conc......	1,200	1,240
	Tons zinc conc......	1,360	1,340
Pilbara	Tons copper ore......	75	58
Rhodesia Broken Hill	Tons lead	1,431	1,320
Sulphide Corporation ..	Tons lead conc. ...	1,922	1,846
	Tons zinc conc	3,230	3,085
Tanganyika	Tons copper	2,783	2,807
Zinc Corporation	Tons zinc conc......	9,490	9,090
	Tons lead conc. ...	902	791

Imports of Ores, Metals, etc., into United Kingdom.

		September	October
Iron Ore	Tons .	89,379	140,508
Manganese Ore	Tons .	3,731	3,164
Iron and Steel	Tons .	206,127	172,769
Copper and Iron Pyrites	Tons .	19,520	21,030
Copper Ore, Matte, and Prec.	Tons .	8,515	3,257
Copper Metal	Tons .	5,760	6,869
Tin Concentrate	Tons .	2,320	1,524
Tin Metal........................	Tons .	1,974	3,735
Lead, Pig and Sheet	Tons .	11,954	6,225
Zinc (Spelter)	Tons .	4,480	11,078
Quicksilver	Lb. .	7,800	10,202
Zinc Oxide......................	Tons .	474	358
White Lead	Cwt. .	4,344	6,369
Barytes, ground	Cwt. .	32,892	34,228
Phosphate	Tons .	42,240	29,256
Mica	Tons .	96	91
Sulphur	Tons .	—	497
Nitrate of Soda.................	Cwt. .	57,411	148,138
Petroleum : Crude	Gallons	11,166,374	15,432,616
Lamp Oil	Gallons	8,668,040	8,558,514
Motor Spirit	Gallons	20,024,380	21,049,631
Lubricating Oil	Gallons	1,239,582	5,351,509
Gas Oil	Gallons	7,530,440	5,269,963
Fuel Oil	Gallons	46,421,748	54,175,363
Paraffin Wax	Cwt. .	37,556	62,269
Turpentine	Cwt. .	15,638	58,886

Output of Tin Mining Companies.

In Tons of Concentrate.

	August	Sept.	Oct.
	Tons	Tons	Tons
Nigeria :			
Associated Nigerian	—	—	—
Bisichi	36	40	45
Bongwelli	—	—	—
Champion (Nigeria)	—	—	—
Dua	—	—	—
Ex-Lands	—	30	30
Filani	6	6½	6½
Gold Coast Consolidated	2	3	3
Gurum River	13	12	11
Jantar	—	—	—
Jos	6	6½	8
Kaduna	1[illegible]	17½	19
Kaduna Prospectors	[illegible]	12¼	13¼
Kano	—	—	—
Keffi Consolidated	—	21	20
Lower Bisichi	4	5¼	3½
Lucky Chance	—	—	—
Minna	—	—	—
Mongu	45	47½	60
Naraguta	50	50	50
Naraguta Extended	24	25	25
Nigerian Consolidated	9	7½	6¾
N.N. Bauchi	82½	83½	55
Offin River	—	—	—
Rayfield	26	21	20
Ropp	128	165	133
Rukuba	5	5	4
South Bukeru	—	13	11
Sybu	—	—	—
Tin Fields	11	14	15
Yarde Kerri	7	7	7
Federated Malay States :			
Chenderiang	—	75*	—
Gopeng	89	89	92
Idris Hydraulic	19¼	20¾	19½
Ipoh	19¼	18	25¼
Kamunting	—	74*	—
Kinta	35¼	35¾	41¾
Lahat	43	47¼	53½
Malayan Tin	83½	77½	77½
Pahang	216	226	211
Rambutan	15	15½	18
Sungei Besi	48	46	48
Tekka	37	39	39
Tekka-Taiping	36	30	23
Tronoh	30	17	15
Other Countries :			
Aramayo Mines (Bolivia)	174	200	220
Berenguela (Bolivia)	28	32	29
Briseis (Tasmania)	10	13	20
Deebook Ronpibon (Siam)	21½	30	30
Leeuwpoort (Transvaal)	—	93*	—
Macreedy (Swaziland)	—	—	—
Renong (Siam)	111	90½	84½
Rooiberg Minerals (Transvaal)	50	50	—
Siamese Tin (Siam)	121	102½	119
Tongkah Harbour (Siam)	113	84	60
Zaaiplaats (Transvaal)	—	—	—

* Three months.

Nigerian Tin Production.

In long tons of concentrate of unspecified content.

Note.—These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual outputs.

	1916	1917	1918	1919	1920	1921
	Tons	Tons	Tons	Tons	Tons	Tons
January	531	667	678	613	547	438
February	528	646	668	623	477	370
March	547	655	707	606	505	445
April	486	555	584	546	467	394
May	536	509	525	483	383	337
June	510	473	492	484	435	423
July	506	479	545	481	484	494
August	498	551	571	616	447	477
September	535	538	520	561	528	595
October	584	578	491	625	626	546
November	679	621	472	536	544	—
December	654	655	518	511	577	—
Total	6,594	6,927	6,771	6,685	6,022	4,499

Production of Tin in Federated Malay States.

Estimated at 70% of Concentrate shipped to Smelters Long Tons.

	1917	1918	1919	1920	1921
	Tons	Tons	Tons	Tons	Tons
January	3,558	3,030	3,765	4,265	3,298
February	2,755	3,197	2,734	3,014	3,111
March	3,286	2,609	2,819	2,770	2,190
April	3,251	3,308	2,858	2,606	2,692
May	3,413	3,332	3,407	2,741	2,884
June	3,489	3,070	2,877	2,940	2,752
July	3,253	3,373	3,756	2,824	2,734
August	3,413	3,259	2,956	2,786	3,051
September	3,154	3,157	3,161	2,734	2,338
October	3,436	2,870	3,221	2,837	3,161
November	3,300	3,132	2,972	2,573	—
December	3,525	3,022	2,409	2,838	—
	39,833	37,370	36,935	34,928	28,211

Stocks of Tin.

Reported by A. Strauss & Co. Long Tons.

	Sept. 30	Oct. 31	Nov. 30
Straits and Australian Spot	1,748	2,168	2,112
Ditto, Landing and in Transit	510	966	483
Other Standard, Spot and Landing	4,226	5,194	5,948
Straits, Afloat	2,000	1,655	1,960
Australian, Afloat	190	175	70
Banca, in Holland	3,934	3,916	4,369
Ditto, Afloat	954	1,250	205
Billiton, Spot	241	126	121
Billiton, Afloat	130	63	31
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	425	840	900
Total Afloat for United States	4,663	4,497	4,671
Stock in America	1,756	2,041	1,316
Total	20,777	22,891	22,247

Shipments, Imports, Supply, and Consumption of Tin.

Reported by A. Strauss & Co. Long tons.

	Sept.	Oct.	Nov.
Shipments from :			
Straits to U.K.	1,870	1,675	1,395
Straits to America	3,000	2,075	1,985
Straits to Continent	430	775	685
Straits to other places	615	475	250
Australia to U.K.	25	50	150
U.K. to America	390	210	800
Imports of Bolivian Tin into Europe	324	1,275	977
Supply :			
Straits	5,300	4,525	4,065
Australian	25	50	150
Billiton	100	63	31
Banca	1,085	1,975	1,233
Standard	811	290	559
Total	7,321	6,903	6,038
Consumption :			
U.K. Deliveries	1,707	1,808	2,330
Dutch ,,	329	255	427
American ,,	2,605	2,280	3,250
Straits, Banca & Billiton, Continental Ports, etc.	940	446	675
Total	5,581	4,879	6,682

Outputs Reported by Oil-producing Companies.

		August	Sept.	Oct.
Anglo-Egyptian	Tons	14,324	13,451	12,865
Anglo-United	Barrels	9,550	9,500	10,500
Apex Trinidad	Barrels	94,398	48,305	9,100
Astra Romana	Tons	27,013	—	—
British Burmah	Barrels	81,405	74,940	76,412
Caltex	Tons	13,340	12,630	13,032
Dacia Romana	Tons	305	278	250
Kern River	Barrels	96,061	97,118	106,790
Lobitos	Tons	9,169	8,631	8,911
Roumanian Consol	Tons	2,588	2,276	2,222
Santa Maria	Tons	1,286	—	1,357
Steaua Romana	Tons	22,760	19,485	19,331
Trinidad Leaseholds	Tons	11,800	10,950	11,900
United of Trinidad	Tons	4,291	5,700	6,215

Quotations of Oil Companies' Shares.

Denomination of Shares £1 unless otherwise noted.

	Nov. 7, 1921			Dec. 6, 1921		
	£	s.	d.	£	s.	d.
Anglo-American	4	16	3	5	5	0
Anglo-Egyptian B	1	2	6	1	10	0
Anglo-Persian 1st Pref.	1	1	9	1	3	0
Apex Trinidad	1	12	6	2	0	0
British Borneo (10s.)		6	6		11	3
British Burmah (8s.)	1	0	0		16	3
Burmah Oil	5	15	0	5	15	0
Caltex ($1)		3	0		3	0
Dacia Romano		13	9		15	0
Kern River, Cal. (10s.)	1	1	3		19	6
Lobitos, Peru	3	15	0	4	10	0
Mexican Eagle, Ord. ($5)	3	7	6	4	1	3
,, ,, Pref. ($5)	3	2	6	3	18	9
North Caucasian (10s.)		11	3		12	6
Phœnix, Roumania		7	3		6	6
Roumanian Consolidated		6	9		8	0
Royal Dutch (100 gulden)	36	10	0	36	0	0
Scottish American		2	0		2	0
Shell Transport, Ord.	4	12	6	4	15	3
,, ,, Pref. (£10)	8	2	6	8	5	0
Trinidad Central	2	12	6	3	7	6
Trinidad Leaseholds	1	12	6	1	16	3
United British of Trinidad		12	6		15	0
Ural Caspian		8	0		11	3
Uroz Oilfields (10s.)		6	0		7	0

Dividends Declared by Mining Companies.

Date	Company	Par Value of Shares	Amount of Dividend
Nov. 15	New Heriot	£1	5s.*
Nov. 16	Great Boulder	2s. 6d.	6d. less tax.
Nov. 19	Siamese Tin	£1	2s. less tax.
Nov. 21	Pengkalen	Pref. Ord. £1	5% less tax.
Nov. 21	Tekka-Taiping	£1	3d. less tax.
Nov. 23	Cassel Cyanide	5s.	8d. less tax.
Nov. 23	Pahang Consolidated	Pref. £1	3½% less tax.
Nov. 24	Ashanti Goldfields	4s.	25% less tax.
Nov. 30	Central Mining	£8	6s. tax paid.
Dec. 5	Ivanhoe Gold	£5	1s. 6d. less tax.
Dec. 6	Shell Transport	Ord. £1	2s. tax paid.
Dec. 9	Sulphide Corporation	Pref. £1	5%
Dec. 9	Pato Mines	£1	7s. less tax.
Dec. 9	Oroville Dredging	£1	9d. less tax.

* Second distribution on liquidation.

PRICES OF CHEMICALS. December 7.

These quotations are not absolute; they vary according to quantities required and contracts running.

		£	s.	d.
Acetic Acid, 40%	per cwt.	1	2	6
,, 80%	,,	2	5	0
,, Glacial	per ton	58	0	0
Alum	,,	16	0	0
Alumina, Sulphate	,,	14	10	0
Ammonia, Anhydrous	per lb.		2	2
,, 0·880 solution	per ton	28	0	0
,, Carbonate	per lb.			4
,, Chloride, grey	per ton	37	0	0
,, ,, pure	per cwt.	3	5	0
,, Nitrate	per ton	40	0	0
,, Phosphate	,,	75	0	0
,, Sulphate	,,	14	10	0
Antimony, Tartar Emetic	per lb.		1	6
,, Sulphide, Golden	,,		1	3
Arsenic, White	per ton	40	0	0
Barium Carbonate	,,	10	0	0
,, Chlorate	per lb.			11
,, Chloride	per ton	15	0	0
,, Sulphate	,,	8	0	0
Benzol, 90%	per gal.		3	0
Bisulphate of Carbon	per ton	56	0	0
Bleaching Powder, 35% Cl.	,,	16	0	0
,, Liquor, 7%	,,	6	0	0
Borax	,,	31	0	0
Boric Acid Crystals	,,	65	0	0
Calcium Chloride	,,	9	0	0
Carbolic Acid, crude 60%	per gal		1	7
,, ,, crystallized, 40	per lb.			6½
China Clay (at Runcorn)	per ton	4	10	0
Citric Acid	per lb.		2	5
Copper, Sulphate	per ton	29	0	0
Cyanide of Sodium, 100%	per lb.			11½
Hydrofluoric Acid	,,			7½
Iodine	per oz.		1	0
Iron, Nitrate	per ton	8	0	0
,, Sulphate	,,	3	0	0
Lead, Acetate, white	,,	45	0	0
,, Nitrate	,,	46	0	0
,, Oxide, Litharge	,,	37	0	0
,, White	,,	44	0	0
Lime, Acetate, brown	,,	8	0	0
,, ,, grey 80%	,,	11	0	0
Magnesite, Calcined	,,	21	0	0
Magnesium, Chloride	,,	12	0	0
,, Sulphate	,,	8	0	0
Methylated Spirit 64 Industrial	per gal.		5	0
Nitric Acid, 80° Tw.	per ton	28	0	0
Oxalic Acid	per lb.			9
Phosphoric Acid	per ton	38	0	0
Potassium Bichromate	per lb.			8
,, Carbonate	per ton	23	0	0
,, Chlorate	per lb.			5
,, Chloride 80%	per ton	12	0	0
,, Hydrate (Caustic) 90%	,,	33	0	0
,, Nitrate	,,	49	0	0
,, Permanganate	per lb.		1	1
,, Prussiate, Yellow	,,		1	3
,, ,, Red	,,		2	3
,, Sulphate, 90%	per ton	16	0	0
Sodium Metal	per lb.		1	4
,, Acetate	per ton	27	0	0
,, Arsenate 45%	,,	42	0	0
,, Bicarbonate	,,	12	0	0
,, Bichromate	per lb.			7
,, Carbonate (Soda Ash)	per ton	15	0	0
,, ,, (Crystals)	,,	7	0	0
,, Chlorate	per lb.			4
,, Hydrate, 76%	per ton	26	15	0
,, Hyposulphite	,,	16	0	0
,, Nitrate, 96%	,,	15	0	0
,, Phosphate	,,	20	0	0
,, Prussiate	per lb.			7
,, Silicate	per ton	11	15	0
,, Sulphate (Salt-cake)	,,	4	0	0
,, ,, (Glauber's Salts)	,,	5	0	0
,, Sulphide	,,	22	0	0
,, Sulphite	,,	12	10	0
Sulphur, Roll	,,	13	0	0
,, Flowers	,,	13	0	0
Sulphuric Acid, Fuming, 65%	,,	24	0	0
,, ,, free from Arsenic, 144	,,	6	5	0
Superphosphate of Lime, 30%	,,	5	10	0
Tartaric Acid	per lb.		1	5
Turpentine	per cwt.	3	11	0
Tin Crystals	per lb.		1	5
Titanous Chloride	,,		1	0
Zinc Chloride	per ton	22	10	0
Zinc Oxide	,,	41	0	0
Zinc Sulphate	,,	17	0	0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS:	Dec. 7, 1920			Dec. 6, 1921		
RAND:	£	s.	d.	£	s.	d.
Brakpan	2	17	6	2	15	0
Central Mining (£8)	7	5	0	6	5	0
City & Suburban (£4)		6	6		2	9
City Deep	2	7	6	2	5	0
Consolidated Gold Fields	1	1	3		13	9
Consolidated Langlaagte		15	0		13	9
Consolidated Main Reef		13	0		9	6
Consolidated Mines Selection (10s.)		18	3		14	0
Crown Mines (10s.)	2	7	6	1	17	6
Daggafontein		10	0		2	6
Durban Roodepoort Deep		5	0		4	6
East Rand Proprietary		7	0		5	0
Ferreira Deep		8	9		7	6
Geduld	2	8	9	2	6	3
Geldenhuis Deep		6	6		5	0
Government Gold Mining Areas	4	2	6	4	2	6
Johannesburg Consolidated	1	4	6	1	1	6
Kleinfontein		6	3		5	3
Knight Central		4	6		4	6
Langlaagte Estate		13	9		11	6
Luipaards Vlei		3	0		3	0
Meyer & Charlton	4	7	6	4	0	0
Modderfontein, New (10s.)	3	8	9	3	15	0
Modderfontein B (5s.)	1	10	0	1	7	6
Modderfontein Deep (5s.)	2	2	6	2	2	6
Modderfontein East	1	1	3		7	6
New State Areas	1	7	6	1	1	3
Nourse		8	6		8	6
Rand Mines (5s.)	2	8	9	2	2	6
Rand Selection Corporation	2	15	0	2	10	0
Randfontein Central		11	6		10	0
Robinson (£5)		7	6		9	0
Robinson Deep A (1s.)		12	6		7	6
Rose Deep		16	3		13	6
Simmer & Jack		3	0		2	9
Springs	1	15	6	1	18	9
Sub-Nigel		13	9		11	3
Union Corporation (12s. 6d.)		16	6		14	6
Van Ryn		13	9		12	0
Van Ryn Deep	3	12	6	3	8	9
Village Deep		8	6		8	6
West Springs		16	3		11	3
Witwatersrand (Knight's)		12	6		12	6
Witwatersrand Deep		6	6		8	3
Wolhuter		5	3		4	0
OTHER TRANSVAAL GOLD MINES:						
Glynn's Lydenburg		10	0		8	0
Transvaal Gold Mining Estates		9	6		7	6
DIAMONDS IN SOUTH AFRICA:						
De Beers Deferred (£2 10s.)	13	0	0	9	10	0
Jagersfontein	3	0	0	2	2	6
Premier Deferred (2s. 6d.)	6	10	0	4	5	0
RHODESIA:						
Cam & Motor		8	6		9	6
Chartered British South Africa		13	6		11	6
Falcon		10	6		4	3
Gaika		11	0		10	0
Globe & Phœnix (5s.)		19	6		12	6
Lonely Reef	2	10	0	2	3	9
Rezende	2	15	0	3	5	0
Shamva	1	10	0	1	10	0
WEST AFRICA:						
Abbontiakoon (10s.)		2	6		2	0
Abosso		7	6		6	6
Ashanti (4s.)		15	0		14	6
Prestea Block A		2	0		1	6
Taquah		11	3		8	6
WEST AUSTRALIA:						
Associated Gold Mines		3	0		3	3
Associated Northern Blocks		3	9		2	0
Bullfinch (5s.)		2	3		1	0
Golden Horse-Shoe (£5)		17	6		12	6
Great Boulder Proprietary (2s.)		6	9		5	6
Great Fingall (10s.)		1	6		1	0
Hampton Celebration		3	9		2	6
Hampton Properties		6	3		4	3
Ivanhoe (£5)	1	2	6		17	6
Kalgurli		12	6		17	3
Lake View Investment (10s.)		13	0		7	0
Lake View and Star (4s.)		2	6		2	0
Oroya Links		1	6		1	3
Sons of Gwalia		5	0		3	6
South Kalgurli (10s.)		6	6		7	6

GOLD, SILVER, *cont.*	Dec. 7, 1920			Dec. 6, 1921		
OTHERS IN AUSTRALASIA:	£	s.	d.	£	s.	d.
Blackwater, New Zealand		8	9		2	6
Waihi, New Zealand	1	10	0	1	1	3
Waihi Grand Junction, New Z'lnd.		8	9		7	6
AMERICA:						
Buena Tierra, Mexico		6	3		1	9
Camp Bird, Colorado		8	6		3	0
El Oro, Mexico		12	6		8	3
Esperanza, Mexico	1	1	3		15	0
Frontino & Bolivia, Colombia		8	9		5	0
Kirkland Lake, Ontario		15	0		11	0
Le Roi No. 2 (£5), British Columbia		4	0		2	6
Mexico Mines of El Oro, Mexico	6	0	0	3	10	0
Nechi (Pref. 10s.), Colombia		8	6		4	0
Oroville Dredging, Colombia	1	3	9	1	1	3
Plymouth Consolidated, California		17	6		3	9
St. John del Rey, Brazil		14	6		16	0
Santa Gertrudis, Mexico		14	3		5	6
Tomboy, Colorado		7	6		5	0
RUSSIA:						
Lena Goldfields		15	0		5	0
Orsk Priority		10	0		5	0
INDIA:						
Balaghat (10s.)		6	6		7	3
Champion Reef (2s. 6d.)		2	3		1	6
Mysore (10s.)		12	6		10	9
North Anantapur		5	0		2	6
Nundydroog (10s.)		2	6		7	9
Ooregum (10s.)		10	0		10	9
COPPER:						
Arizona Copper (5s.), Arizona	1	17	6		17	6
Cape Copper (£2), Cape and India		17	0		10	0
Esperanza, Spain		5	0		5	0
Hampden Cloncurry, Queensland		7	6		5	0
Mason & Barry, Portugal	1	10	0	2	15	0
Messina (5s.), Transvaal		4	0		3	0
Mount Elliott (£5), Queensland	1	0	0		10	0
Mount Lyell, Tasmania		16	6		13	9
Mount Morgan, Queensland		12	6		13	6
Namaqua (£2), Cape Province	1	7	6		17	6
Rio Tinto (£5), Spain	24	10	0	26	15	0
Russo-Asiatic Consd., Russia		10	6		7	0
Sissert, Russia		11	3		5	0
Spassky, Russia		15	0		7	6
Tanganyika, Congo and Rhodesia	1	5	0		18	9
LEAD-ZINC:						
BROKEN HILL:						
Amalgamated Zinc	1	1	3		15	0
British Broken Hill	1	5	0	1	6	3
Broken Hill Proprietary	2	6	3	1	8	9
Broken Hill Block 10 (£10)		17	6		12	6
Broken Hill North	1	17	6	1	12	6
Broken Hill South	1	16	3	1	8	9
Sulphide Corporation (15s.)		15	9		10	3
Zinc Corporation (10s.)		14	0		11	0
ASIA:						
Burma Corporation (10 rupees)		9	0		5	6
Russian Mining		7	6		4	6
RHODESIA:						
Rhodesia Broken Hill (5s.)		8	0		5	3
TIN:						
Aramayo Mines, Bolivia	2	17	6	1	15	0
Bisichi (10s.), Nigeria		8	0		5	9
Briseis, Tasmania		4	3		3	0
Chenderiang, Malay		15	0		10	0
Dolcoath, Cornwall		1	9			9
East Pool (5s.), Cornwall		8	0		3	0
Ex-Lands Nigeria (2s.), Nigeria		2	6		1	6
Geevor (10s.), Cornwall		6	3		2	6
Gopeng, Malay	1	12	6	1	13	9
Ipoh Dredging, Malay		13	9		7	6
Kamunting, Malay	2	10	0	1	0	0
Kinta, Malay	2	0	0	1	12	6
Lahat, Malay		12	0		10	0
Malayan Tin Dredging, Malay	1	10	0	1	1	3
Mongu (10s.), Nigeria		15	0		12	6
Naraguta, Nigeria		12	6		13	9
N. N. Bauchi, Nigeria (10s.)		3	3		2	0
Pahang Consolidated (5s.), Malay		9	6		5	6
Rayfield, Nigeria		5	6		4	0
Renong Dredging, Siam	1	15	0	1	3	9
Ropp (4s.), Nigeria		7	9		5	9
Siamese Tin, Siam	2	15	0	1	13	9
South Crofty (5s.), Cornwall		10	6		3	3
Tehidy Minerals, Cornwall		11	3		5	0
Tekka, Malay	1	0	0		17	6
Tekka-Taiping, Malay	1	2	6	1	0	0
Tronoh, Malay	1	7	6	1	1	3

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also notices of new books and pamphlets, lists of patents on mining and metallurgical subjects, and abstracts of the yearly reports of mining companies.

THE MINERAL RESOURCES OF UGANDA

The first annual report of the Geological Department, Uganda Protectorate, covers the year ended March 31, 1920, and it is written by E. J. Wayland and W. C. Simmons, Chief and Assistant Geologist respectively. We give herewith some quotations relating to the general geology and the mineral occurrences. One part that we omit deals with the theory of the Rift Valley. It may be mentioned here that the Rift Valley was the subject of a paper by Mr. Wayland read before the Royal Geographical Society last month.

GEOLOGY.—The rocks of Uganda may be divided among eight age-groups. They are dealt with in the order of their comparative antiquity, which is as follows :—

(1) The Archæan Complex.
(2) The Argillite Series.
(3) The Post-Argillite Intrusives.
(4) The Older Lateritic Deposits and Associated Gravels.
(5) The Mount Elgon Series.
(6) The High-level Gravels and Recent Lateritic Deposits.
(7) The Mufumbiro Volcanics.
(8) Recent Deposits.

(1) The basement of Uganda, like that of Africa in general, is composed of a series of very ancient crystalline rocks, which are almost certainly Archæan in age. Among them a moderately fine grained biotite-gneiss, or gneissose-granite, is conspicuous ; but associated with it are many other types of granitic, foliated, and schistose rocks, most, if not all, of which may be paralleled in other parts of the continent. The biotite-gneiss frequently contains monazite and zircon, so that material for an age-determination by radio-active methods is not lacking. Quartz-schists and mica-schists are both present. In the former the ferro-magnesian constituent, which is always recessive, is represented by a white mica, commonly sericite, while both biotite and normal muscovite schists occur. Near Seconyoni, Archæan outcrops display some highly crumpled sericite-schists, which are probably the metamorphic equivalents of highly felspathic quartzose rocks. In some parts (north-east of Soroti, for example) every gradation can be traced between a biotite-schist and an augen gneiss on the one hand, and between the same augen rock and a porphyritic granite on the other. Rocks with well-developed augen structure are of local occurrence ; a fine example is to be seen near Moroto Post. It occurs in association with what may be provisionally regarded as a sheared pegmatite, and consists of greyish felspar phenocrysts, with indefinite boundaries, merging into a white granular felspathic matrix, which is divided by dark mica flakes into eye-shaped pieces varying in length from half an inch to several inches. The irises of many such "eyes" are represented by grey felspar phenocrysts. Imbedded in the more micaceous parts are reddish to mauve crystals of zircon, which may reach a quarter of an inch in length.

More or less hornblendic rocks are common in the Archæan group, as are hornblende-schists, and hornblende-epidote-schists. These are well developed in the Eastern Province, where actinolite and kyanite schists occur, as do sillimanite-bearing rocks, and dolomitic marbles. The granites and gneissose-granites sometimes contain (as at Soroti, for example) dark inclusions of an older basic rock, the composition of which has yet to be determined. Many of the porphyritic granites show a very remarkable parallelism of the phenocrysts, traceable over wide areas and coincident with the strike of the country.

While no order of sequence of the Archæan rocks is yet certainly known, there is some evidence for supposing the more schistose representatives to occur with the dolomites in the upper part.

Intruded into the Archæan complex is a pyroxene granite, bearing strong resemblance to the charnockite of South India and Ceylon. In general, it appears to be pre-argillite in age, but Mr. Simmons has recorded an instance where a pyroxene-bearing granite has apparently been intruded into a post-argillite fault ; the field relations of this occurrence, however, are not very distinct.

Gabbros and diorites occur in the Archæan group, and a highly quartzose frequently finely jointed and much crumpled rock is characteristic.

In many places pegmatites, which may be more or less normal or may be differentiated into highly quartzose and highly felspathic reefs, cut across or run parallel with the foliation of the gneisses and schists. The local abundance of pegmatites in the ancient crystalline complex, and their almost entire absence in the neighbouring argillites, suggests a pre-argillite age for these intrusives. A few instances of normal pegmatites cutting the argillites are known, but these may be correlated with a later granite.

The most extensive development of Archæan rocks in the country appears to be in the Northern and Eastern Provinces. They occur in many places in the Buganda and Western Provinces, faulted in among the argillites and coming to grass in blocks and ridges, particularly in connexion with the curious low-lying areas described under the name of "arenas." Traced in a westerly direction, through the Buganda and Western Provinces, the crystalline rocks become increasingly conspicuous and occupy successively higher altitudes, until Ruwenzori is reached, where they attain their maximum height in the continent of Africa.

(2) Resting unconformably upon the foliated beds of the Archæan is the Argillite Series, a thick series of clay-like rocks varying considerably in composition and colour. Although those strata among them that have suffered little from the more drastic

types of metamorphism vary considerably in appearance and hardness, gradations between extreme types are so common that there can be no doubt that the series is essentially one, and although they vary in composition from practically pure hydrated silicate of alumina to a highly siliceous deposit, the gradations are so fine that there is no alternative but to adopt a single name for the whole. Since clay is no longer a term of chemical significance, the name Argillite Series is tentatively proposed in recognition of the essentially clay-like or shale-like appearance of the majority of its members. The name is purely provisional, and has obvious disadvantages; it will be replaced by another when the age of the beds is known. It is probable that they will turn out to be of Karoo age. Red and brown are the more usual colours of the clay members of the Argillite Series, but grey, yellowish shades, banded white, blue, and black are among the variations recorded. The rocks are extremely fine grained and rather absorbent, a characteristic which is noticeable in the more siliceous varieties. They do not, as a rule, display jointing to any marked extent. Hollow cavities resembling the salt pseudomorphs of the British Trias are locally abundant.

Interbedded with the clay rocks are quartzites, conglomerates, and sandstones. The first of these frequently carry pyrites and pyrrhotite scattered through them; the second often resemble very closely the banket of the Rand; while the last recall some beds of the millstone grit of Britain.

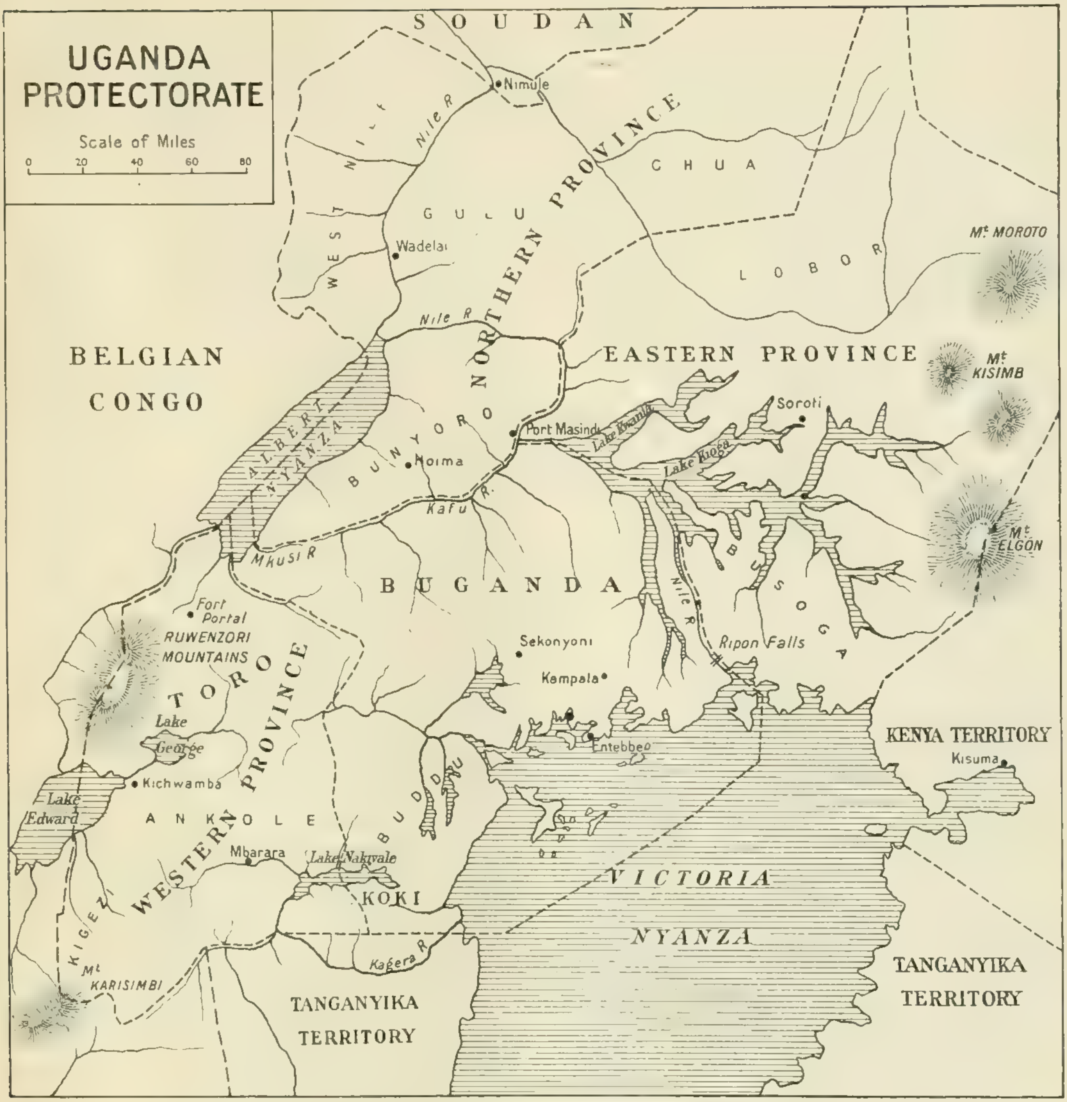
(3) The Post-Argillite intrusives may be broadly divided into acid and basic groups. Among the former quartz reefs are the most obvious, since they do not laterize and often stand out in bold relief from the red soil surrounding them. Frequently they carry iron ores which sometimes become very conspicuous; hematite is the commonest of these ores. It often happens that hematite is replaced by goethite at the surface. Quartz-tourmaline reefs, associated with highly tourmalinized argillites, are locally developed, while pegmatites and tourmaline-pegmatites, in which the tourmaline seems to take the place of mica, are known. Large granitic intrusions, probably laccolitic in form, make their presence felt in some areas; with them, probably, the smaller and more highly differentiated intrusives are genetically connected. The intrusions belonging to the basic group are chiefly of the nature of diabases, picrites, and pyroxenites. The basic intrusives generally give rise to a brilliant red soil, which appears to be extremely fertile. Not infrequently they can be traced for a mile or more in approximately straight lines. One of these picrite dykes holds back the Nile at the Ripon Falls, another at the Owen Falls near by.

(4) The Older Lateritic Deposits, which do not appear to be forming to-day, cap flat-topped hills which characterize Uganda and the adjoining country. They do not present any exceptional petrographical features, and may be matched in many other places in the tropics.

(5) With the exception of a basement of sedimentary (often conglomeratic) beds, which in all probability do not strictly belong to the series, the Mount Elgon Series consists entirely of volcanic rocks.

(6) As regards this division, high-level gravels and silts are very extensively developed in Uganda; they are associated with all the larger rivers and lakes, and are found at varying levels up to the 4,000 ft. contour in the case of the old lake deposits. They are to be found in small feeder valleys, where they may be more than 4,000 ft. above sea-level, as well as flanking large river valleys. In all instances investigated at present the main deposits have been shown to rest on old valley or lake bottoms above those of the present waters. The bottom gravels are flood-like in character, and the pebbles are often highly polished. Terracing occurs, two terraces being generally traceable. It is to be noted that the terraces are carved out of the gravel deposits by descending rivers; they are not cut out of the rocks. The fact that pot-holes are sometimes to be found on the ancient bottoms, which are overlapped by reason of the great horizontal spread of the alluvials above them, suggests that at one time the rivers rose considerably; in which case we should expect to find corroborative evidence in the lake depressions. The Albert Nyanza affords a good example; an old lake bottom (mud) well above the present level of the water and extending landwards to the base of the escarpment is overlain by extensive alluvial deposits which attain an altitude of more than 100 ft. above lake level; they are horizontally stratified, and are composed of a heterogeneous collection of boulders, stones, sand, and clay. The boulders, which are generally subangular, grow less common as the series is ascended. The horizontal stratification shows that the beds are not talus accumulations; while their constitution declares them to be of the nature of flood deposits.

(7) The Mufumbiro volcanoes rise from a plain well below the general level of the country to the east and north of it. The cones are well formed and large, the greatest (Karissimbi), situated within the boundaries of the Belgian Congo, reaches an altitude of 14,630 ft. They bear all the indications of recency, and one, Namlagira (? Namalagira), also in Congo territory, is still mildly active. As the necessary materials for the production of good petrographical sections are yet awaited little has been done in the matter of detailed rock determination, but it would appear from a few specimens examined that a good deal of the Kigezi lava is of the nature of olivine basalt. It is to be noted, too, that the olivine, which is sometimes present in individuals of ½ in. or more in length, is remarkably fresh, while the lavas and ashes themselves can be shown to have been spread over a landscape which is essentially that of the present day. They cover soils which must be comparatively recent. At the junction of the soils and the volcanic deposit, springs, the result of rain soakage through the latter, make their appearance. When the volcanic beds overlying such a soil happen to be ash beds they tend to slide over the surface of the soil, which is rendered slippery by the percolating water, and come gliding down to lower levels as land slips. Larger falls may be expected. Not all the craters in Kigezi are of the usual lava-emitting type. Many of them, especially those situated close to and among the surrounding argillite hills, are explosion craters blown through the rocks; they have emitted large quantities of ashes and bombs which now cover the country for miles around. Craters of this type probably represent an early phase in the volcanicity of the region. It would appear that these explosions were due to steam generated from water, which once occupied the depression in which the craters now stand. The eruption started, in fact, in the floor of a lake,



the remnants of which are still to be seen around the volcanoes. The lava cones were formed subsequently, probably immediately after the explosion phase. Many of the explosion craters were obliterated by the immense flows of lava which were subsequently poured out. No doubt many passed from explosion craters into lava craters; some, however, chiefly those in among and against the hills, were preserved by virtue of their screened position. There is evidence, too, to show that the main cones in the vicinity gave vent to three outpourings of lava, for they are still to be traced in horizontal sheets, whose edges form step-like terraces one above the other running east and west and facing northwards. Exactly when the major outpourings took place in the Kigezi district is uncertain, but the most conspicuous are, geologically speaking, very recent. Sections are not wanting which show that the present scenery and soil are continued beneath the ashes and lavas, and it can hardly be doubted that most, if not the whole, of the deposits have been spread over the area within human times. But it is possible that those situated further west are directly connected with the formation of the West Rift, with which the earliest outpourings might be contemporaneous.

Other volcanic rocks, some of which are moderately recent, are to be seen in the extreme west of Ankole and along the eastern side of Ruwenzori to some way beyond Fort Portal. Here, too, explosion craters are common, though small lava cones occur as well. At Kichwamba, on the eastern side of Kazinga Channel between Lakes George and Edward, the eruptions belong to two distinct periods; for the sub-aqueous tuffs by which the older volcanics are represented have been drilled through by explosions, a few of which have produced large circular

chimneys with vertical sides. A good many of these craters hold water, thereby giving rise to the famous crater lakes of the district; one of these contains water rich in soda and other salts. Near Fort Portal volcanic tuffs containing the impression of fossil leaves can be seen overlying ancient lake deposits, which are now high and dry above the neighbouring streams. Most of the tuffs contain a high percentage of calcium carbonate. It is probable that the older tuffs of Ankole, which form the western fault escarpment of the rift in this part, are connected, as may be those of Elgon, with earth-movements that preceded and eventually led up to the final phase in the formation of the African rift valleys. Provisionally, at any rate, the older Ankole tuffs may be correlated with the Mount Elgon lavas, while the newer tuffs and more recent cones of Ankole and of Toro may be grouped with the Kigezi volcanics. Whether the Congo volcanoes are situated within the rift depression or not, it is impossible to say, but there is no evidence to show that the high ground to the east of the Mufumbiro mountains in Uganda is separated from the low country from which the volcanoes rise by a fault; indeed, there is evidence to the contrary.

(8) The Recent Deposits consist of the usual clays, muds, sands, and gravels forming at the present day. They call for no special remark.

THE KAFU ALLUVIAL DEPOSITS.—Investigations were made of the geology of the Hoima district, Bunyoro, in order that some evidence might be obtained as to likely deep-lead deposits. The Kafu river is a big swamp system, and though it contains little water now, except when heavy rains have flooded the papyrus-choked swampy flats, and never any big flow, yet it is obvious from the size of the flat valley and the extent of the flood gravel deposits that it must, at one time, have been a big river. The present Kafu rises in a system of swamps, from which also the Nkussi river runs the opposite way into Lake Albert. It has been pointed out by the geologists that the Kafu must have risen at one time on the dome which has been let down by the rift faults to form the Lake Albert depression, and the River Nkussi has captured the head-waters of the Kafu and now flows back into the depression. The Kafu deposits have been found to contain small quantities of gold and more appreciable amounts of stream tin, so that these problems are not of purely academic interest, but become of the utmost importance in trying to locate richer deposits of these minerals.

The Kafu is now a papyrus-choked swamp, varying in width from a third to half a mile and more, and with a small water channel in the centre. The papyrus stands either in stagnant or feebly running water or in moist clay, according to the season or situation. At the sides are clay flats overgrown with rank grass and studded with acacia-thorn and other swamp-loving trees, and at the margins of this flat are slopes of gravel which spread out to the valley sides. The valley is of small slope and it is always difficult to draw a boundary between the laterite deposits of the sides and the true alluvials. Near the Kafu ridge on the Kampala-Hoima Road, the river deposits are about 2 miles wide, and this is about the average width, though they may extend to 3 miles or narrow to only a few hundred yards, as at the Mugabi ridge. The Kafu having been once a vigorous stream able to transport huge flood gravels and deposit them over its bed, it follows that the ancient gravels (or rather the gravels of the middle period, the most ancient being in terraces at the sides) might lie at the bottom of its valley under the later clay deposits, if its history since the loss of its watershed had been simply a dying off in the flow of water and a consequent "sudding up" of the channel. This is only partly the case, and though it has not been found possible to prospect the swamp near the river in the papyrus-belt by pits, owing to flooding, yet such evidence as is obtained points to the probability that the present stream deposits in the centre of the river are the lowest, though the ancient gravels are found to lie, under a thickness of clay up to 20 ft., at a level which is below the present stream bottom, but not necessarily below the present or recent erosion valley, which is now filled with mud. This is a point which will be easy of investigation when it is possible to put some small trial bores in the papyrus-belt. The rather hopeful results that are detailed here have been obtained from prospect pits only, on such sites as it was found possible to dig them.

The Chief Geologist, during his preliminary reconnaissance, had put two pits on the Singo side of the Kafu, one near the river and another a mile away on the gravel terrace, and he obtained a concentrate with small quantities of gold, which led to his pronouncing the gravels hopeful. The Assistant Geologist was therefore instructed to carry on with the prospecting of the gravels, and he started excavation on the Bunyoro as well as on the Singo side of the river, where the Kampala-Hoima road crosses it. The Bunyoro side is very different from the Buganda side at this place, for whereas on the Singo side the gravel flat is a mile wide, and the 3,600 contour lies 3 miles up from the stream, on the Bunyoro side the flat is narrow and the 3,600 contour is only a mile off. The first pit on the Bunyoro side bottomed on a white quartz reef at 9 ft. in the gravel of the terrace and yielded no gold, while on the Singo side the thin gravels just below the terrace yielded only minute traces of gold. It was then decided to dig a pit through the lay, nearer the stream on the Bunyoro side. This pit showed 15 ft. of stiff clay, which was most difficult to excavate, but at the bottom a gravel averaging 6 in. thick was struck, which rested on the decayed gneiss, a mixture of kaolinized felspar and quartz which had been found in all the other pits, and which at depth becomes harder and merges into more easily recognized gneiss. The bottom gravel here yielded fine gold and a few coarser grains, which gave distinct encouragement to continue prospecting. A pit was now put at the edge of the swamp on the Bunyoro side, and it was here found that after passing through 5 ft. of clay there was a sand bed of 9 ft. 6 in. thickness on the gravel bed, which was only 6 in. thick, and rested on a broken-down mica-schist in place of the gneiss. The gravel contained boulders of small size and yielded a much greater quantity of gold, though actual amounts were still far from approaching payable values. The gold occurs in little flattened grains, two or three of these grains of gold in every pan, and fine gold in appreciable amount. On the Singo side other pits failed to yield more than small traces of gold, so work was now confined to the Bunyoro side, and pits were put as near the present river-bed as the water would allow. The beginning

of the rains hindered the work at this stage and pit sites had to be chosen on the dryer places in the sides. Pit 11 was 350 ft. up stream from Pit 6, and it yielded concentrate in much greater amount from a gravel and boulder bed that was only 3 in. thick overlain by 3 ft. of clay on 11 ft. 6 in. of sands, which were easy to remove. This concentrate was sent to headquarters, and the Geologist was able to make a separation with the somewhat crude apparatus at his command, and found that this concentrate which was obtained from 6¼ cu. ft. of gravel, overlain by 370 cu. ft. of barren deposits, weighed 865 grammes, of which about 120 grammes (or 4½ oz.) were tin and the gold rather less than one grain. Among the gold was one larger grain than usual, about ⅛ in. long. It has been calculated from these figures that the values obtained for the pay dirt were about 1s. 6d. to the cubic yard for this pit, and it is to be noticed that the overburden here is quite barren but easy to remove. Other pits were put down near this site, and about the same amounts of concentrate obtained, but the best results were from Pit 15, which was 200 yards up stream from 11; here 18 in. of the gravel was overlain by 15 ft. of stiff grey clay, which was difficult to remove. The gravel was thicker and the yield of concentrate per yard considerably more, and gold about the same. Pits further up stream failed to yield any more concentrate or gold, as it seemed that the deep channel had swung away out from the Bunyoro shore. The ancient meanders of a sudded-up river whose channel is filled with clay deposits are difficult to follow, and to expedite the work simple boring apparatus would have much helped. Pit 16 was about 350 yards up from 15, and yielded a little less concentrate and about the same quantity of gold from a gravel bed 3 ft. 6 in. thick under 11 ft. of clay. Because it was found that the deep channel now swung away from the Bunyoro side a move was made up stream to Mugabi, where a ridge of quartz-gneiss strikes across the stream and the Kafu swamp narrows down to 250 yards across, though the ridge is also breached in another place north of the Kafu, and the river must once have used both gaps. The Mugabi site was chosen, partly because it was the only place accessible to the Kafu about there, and partly because it seemed that evidence would be there obtained as to whether the old valley was eroded deeply or not. The Mugabi ridge must have held up the river and caused a back-water, so that the usual gravels were not deposited there, or have been removed later. The lead was partially located well out in the swamp (as far out as a pit could be dug), and the usual concentrate with gold was obtained in small quantity in a coarse sand and boulder bed overlain by 16 ft. of moist clay. A line of pits was dug parallel to the Mugabi ridge, behind it, and extending from the Kafu to past the other gap, now occupied by only a small swamp. No further traces of gold, and only small patches of the gravels were located in these pits, thus proving that the lead lies out in the centre of the Kafu at this place. Rains had now begun to delay the work very much, and it was found advisable, for the want of boring apparatus, to leave the Kafu and take up the geological survey of part of Bunyoro.

The concentrates from the pits nearest to the swamp from the whole length of the river prospected are very uniform in character. They consist essentially of the following :—

Dark grains, black, brown, etc.: Ilmenite, magnetite, tin-stone, monazite, etc.
Pink grains: Garnet.
Bright red grains: Garnet, etc.
Green grains: Epidote and diopside.
Colourless grains: Zircons, apatite, quartz, etc.

The concentrate also yielded gold in coarse grains, of two types, flattened discoidal and much worn, and also more irregular shaped grains, with always very fine gold. On the average it seems to consist of about one-seventh part of its weight of tin-stone and to yield about two or three grains of gold to the cubic yard. So that the value of a cubic yard of the gravel is probably about 1s. 6d., but the thick, barren overburdens decrease this value very much.

The gravel consists almost wholly of quartzose rocks, either pure colourless quartz, or white, yellow, and brown quartz, and quartzites of various types, and differing much in the coarseness of grain. The pebbles are nearly all round or ellipsoidal and very much waterworn, so much so that the few fragments that are not waterworn can be soon sorted out. These angular ones vary in size from boulders a foot in diameter to minute fragments, and consist of the following: A hard, red, siliceous rock, resembling an impure jaspar, agate fragments, a few black siliceous rocks, fragments of quartz, and a few odds and ends. These angular fragments occur sparingly in the terrace gravels, but are more abundant, though never very abundant, in the gravel from the bottom of the valley. There they occur with boulders usually cuboidal in shape, and with partly rounded edges in some cases. Practically all the sources of these boulders have been located close above their place of occurrence. For instance, "greenstone" from an outcrop between the river and the road, gneiss of hard quartzose type from a ridge striking across the river 2 miles up from the road, quartzose boulders from the Mugabi ridge, etc. Also all the other subangular fragments (with the exception of the agate and jasper not located, but suspected to occur in the Argillite Series) can be ascribed to sources not far distant from the place in the river bed where they are found. The gravel always has a quantity of quartz in it, varying in size from the largest pebbles down to the minutest sand, and quite commonly the gravel has also a clayey matrix binding it into a hard mass; but in most of the pits yielding the best concentrates the clay is absent, and the bed is a brilliant yellow sandy gravel. Some of the pebbles in the bottom gravel bed are highly polished, and a few stone tools of human workmanship, also polished by Nature subsequently to the working, were found in the gravel in Pit 15. The polishing in not easy to explain, but it is best exhibited by hard siliceous yellow-ochreous pebbles from a rock probably belonging to the Argillite Series, and there are most of them to be found in pits where the floor is an altered mica schist. The occurrence of Palæolithic implements in the auriferous gravel in Pit 15 is interesting, and serves to prove that the bed was deposited either during or subsequent to the Palæolithic age. Very much more data are needed before the sequence of events in these river deposits can be unravelled, however.

(To be continued.)

GENESIS OF SPANISH PYRITES

At the meeting of the Institution of Mining and Metallurgy, held on November 17, H. F. Collins presented a paper entitled: "The Igneous Rocks of the Province of Huelva and the Genesis of the Pyritic Ore-bodies." We give herewith the summary, followed by extracts from the paper relating to the author's suggestions as to methods of enrichment. Firstly the summary:—

The igneous rocks of the province comprise contemporaneous lava-flows, tuffs, and ashbeds, as well as the granites, diorites, diabases, and porphyries described by previous writers. They all show a certain similarity marking them out as belonging to a definite petrographical province, particularly in regard to the universally low proportion of alkalis and high proportion of iron, and to the general occurrence of oligoclase and augite as the predominant felspathic and ferro-magnesian constituents respectively, the latter being in great part altered to chlorite.

All the rocks contain notable quantities of copper, zinc, and pyrites as accessory constituents.

The diabases and porphyries are most closely related to the ore-bodies; they appear to belong to the same general period, antedating that of the latter, and to exhibit almost every gradation in composition between a basic olivine-dolerite and a siliceous trachyte-porphyry.

As to the relative ages of the igneous rocks, it is easy to dogmatize but thoroughly unsafe to do so in the absence of more detailed study and definite information. The author was formerly inclined to consider the granite as the earliest in point of time of the intrusions, and the diabase as the latest, but only from analogy and on general grounds, since evidence is lacking to justify any positive pronouncement on the subject.

The pyritic ore-bodies have been formed by gradual replacement along shear-zones, mostly at or very close to contacts between the tilted sedimentary rocks and the porphyries and diabases. The sheared rock replaced is in most cases slate, but sometimes porphyry. The solutions that effected the mineralization doubtless had their origin in the underlying magma, from which all the igneous rocks now visible at surface were derived by differentiation.

The pyrites formed by the primary replacement was, beyond the influence of superficial secondary (chalcocite and covellite) enrichment, almost invariably poor in copper (2% and under, generally under 1%).

As the circulation of mineralizing solutions became less violent, owing to cooling and to the local cessation of earth movement, the solutions became relatively more highly charged with copper than with iron, and produced local primary impregnation in the pyrites already deposited, which may be called "deep-seated primary enrichment."

A further enrichment with chalcopyrite has been in many cases effected through the infiltration of solutions laterally from the dykes of diabase and porphyry which so frequently run parallel to the lodes and at a short distance from them; this may be termed "lateral primary enrichment."

We proceed to quote the author in detail as to the enrichments mentioned in the preceding two paragraphs.

The occurrence and extent of what is ordinarily known as secondary enrichment in these pyrites, lodes, and masses, due to the percolation downward of solutions containing copper sulphate derived from the leaching out of the gossan zone, or of the portion of the lode removed by denudation, and the precipitation of the copper (chiefly as chalcocite) upon the underlying unaltered pyrites, are already sufficiently well known. The extent to which the enrichment has progressed downward depends partly upon the depth of ore leached or denuded away, and partly upon the height of the outcrop above the local drainage level of the near-by ravines. It is too often assumed, however, that all local enrichments of the ore-bodies owe their origin to this cause, and that the course of the enriching solutions has been invariably downwards. The author distinguishes in these ore-bodies two other kinds of enrichment which, although both posterior in their occurrence to the formation of the masses, may yet be called "primary" to distinguish them from that resulting from the purely "surface" agencies referred to. These he refers to as "deep-seated" and "lateral" primary enrichment respectively.

In the first-named type the primary chalcopyrite may take the form of myriads of interlacing strings and small patches distributed over a considerable area of the cupreous pyrites, or it may form bunches many pounds in weight of nearly pure chalcopyrite. The author believes that this first type owes its origin to the gradual dying out of energy and falling off of the iron and sulphur contents in the mineralizing solutions, accompanied with a lowering of temperature due to cooling, coupled probably with a lowering of pressure, the result of contraction and possibly also of denudation. The first solutions were most highly charged with iron and sulphur, and the first process of mineralization was to produce enormous quantities of the pyritous slates (with all proportions of pyrites from 20% up to 80%), which are found everywhere throughout the district, and which are known as "azufrones"; these are invariably poor in copper. They are frequently found on the margins of lodes, but frequently alone in large masses unaccompanied by workable ore-bodies. This first stage of mineralization was probably rapid, and brought about by the circulation of large volumes of solution highly charged with sulphur and iron. As cooling proceeded in the intruded and underlying magmas the solutions carried a less proportion of iron and sulphur, and became more highly charged relatively with copper, thus depositing concurrently the intimate mixture of pyrites with chalcopyrite which is known throughout the world as cupreous pyrites. The richness in copper of this primary ore very likely depended largely upon the rapidity of its deposition, for even if the solutions everywhere carried about the same amount of copper (a surmise which would appear to derive some support from the relatively uniform copper contents of all the eruptives in this petrographical province), a higher grade of cupreous pyrites might be deposited from solutions carrying less iron and sulphur or circulating less rapidly and vice versa.

An interesting fact in connexion with this type of "deep-seated primary" enrichment is that with the chalcopyrite is frequently associated blende

and galena in notable quantities, as well as more rarely tetrahedrite and bournonite. The two former minerals occasionally predominate over the pyrites, makin a complex banded ore, which when rich in copper and comparatively low in lead and zinc, is often smelted for its copper contents, but when high in zinc and lead is sold for shipment to works that make a specialty of extracting these metals. When neither the copper nor the zinc is high enough, these ores are sorted out from the copper ores and form a waste product of the mining operations.

The other type of "primary" enrichment to which attention should be drawn is of a very different nature, and lends itself to much interesting speculation in regard to the channels taken by the mineralizing solutions. Thirty or more years ago a Spanish engineer first drew attention to the fact that in a considerable number of cases the ore appeared to be richer in that part of a pyrites mass which was nearest to the dykes of porphyry or diabase that so frequently run parallel with the lodes. The author has examined many of the ore-bodies, with special attention to any shoots of ore that might be noticeable and to their possible origin. Shoots distributed longitudinally are not very common, and they appear to be always explainable on the theory of reopening and later mineralization. Apart from these, however, there are many examples of transverse shoots, and these appear to be generally associated with transverse joints running from wall to wall, somewhat obliquely. Such transverse joints are sometimes very frequent, and they are very often filled with a mixture of chalcopyrite, quartz, and other minerals.

The author gives a number of instances, of which those at the San Platon mine are from the point of view of lateral enrichment more interesting than almost any others in the province. There are at least four principal ore lenses, overlapping both in dip and strike, and they occur wholly in the slate formation, a large dyke of porphyry showing, however, on the hanging-wall, north side, at about, 100 yards distance. In the old mine, worked by open-cut, only one lode was known (the southernmost), the other two being "blind." At the capping of these two lodes they are very narrow and consist of cupreous schists and complex zincy ore with some chalcopyrite, but soon widen and yield rich cupreous pyrites. The extreme northernmost lode or lens, for instance, where first discovered by cross-cutting on the fifth floor, was little more than a joint, as on the fourth floor; on the sixth floor, however, it widened out to 1 m. to 5 m., yielding ore of 4% to 8% copper. The main or south lode yielded rich ore (4% to 6%) at surface from the opencut, being secondarily enriched with chalcocite, but at the fifth floor this ore contains only 0·8% copper, and at the sixth only 0·30%. At the fourth floor on the south or foot-wall side it contains 0·8% to 1% copper; on the north or hanging-wall side 1¾% to 2%. All the lodes show many transverse joints from wall to wall, nearly at right angles, but there is little sign of motion in these and practically no joint filling; the transverse joints, however, mark off transverse blocks in the ore-body, each of which is either richer or poorer than the adjoining block, that is, there appears to have been impregnation by chalcopyrite subsequent to formation, and limited in a sense longitudinally to the ore-body by the cross-joints. Like the south lode, the other two show more chalcopyrite impregnation on the north or hanging-wall than on the south or foot-wall, the average difference being about 1%, for instance, 2½% copper on the hanging side, and 1½% on the foot-wall. A still more interesting feature is that the west end of each lens is always rich and the east end invariably poor Upon closer examination it appears that it is always the part of each lens which is overlapped by the next that is rich. Taking, for instance, the second or so-called north lode, this is rich throughout on the fifth floor (the north lode being always 1% richer on the average than the foot-wall side) and does not much fall off in grade on the sixth floor until the northernmost or new lode comes in to overlap it at its eastern end. Similarly with the other lenses, as each becomes overlapped on its strike and dip by the next successive lens (the general axis of all the lenses being on a line pitching steeply to the NNE.), it becomes impoverished in copper, or rather it is only the part of each lens not so overlapped that has become enriched. The foregoing facts can only be explained upon the assumption that there has been a chalcopyrite enrichment which has come in laterally from the north side of all the ore-bodies alike, that is from the porphyry dyke, which is a very prominent feature in the landscape about a hundred yards to the north of the ore-bodies. Since the enrichment is of chalcopyrite and not of chalcocite, it must be considered as primary in the sense of not being due to the superficial agencies that have caused the ordinary secondary enrichment.

In connexion with this lateral secretion theory, it may be mentioned that the author has shown that the whole of the rocks of the mineral belt of the province of Huelva, whatever their origin and composition, and whether comparatively near to ore-bodies or remote (in some cases at a distance of many miles), contain both copper and pyrites. It is noteworthy also that it is by no means those rocks which are nearest to the ore-bodies that contain the highest proportion of these ore-forming constituents; in several instances, indeed, the contrary would appear to be the case.

CORBOULD'S COPPER EXTRACTION PROCESS

The *Proceedings* of the Australasian Institute of Mining and Metallurgy No. 42, 1921, contains a paper by Percy Burbidge describing the process for leaching low-grade copper sulphide ores, worked out by W. H. Corbould, manager of the Mount Elliott mine, Queensland. This process was mentioned in the Mount Elliott company's last yearly report, to which reference was made in the MAGAZINE for January of this year, and it is believed that it will be applicable to the large reserves of low-grade ore available at that company's mines.

The essentials of the process are as follows :—

(1) Fine grinding followed by a sulphatizing roast.

(2) Agitation with acid solution produced within the process by electrolysis.

(3) Purification of a portion of the mother liquor and electrolytic deposition of the contained copper,

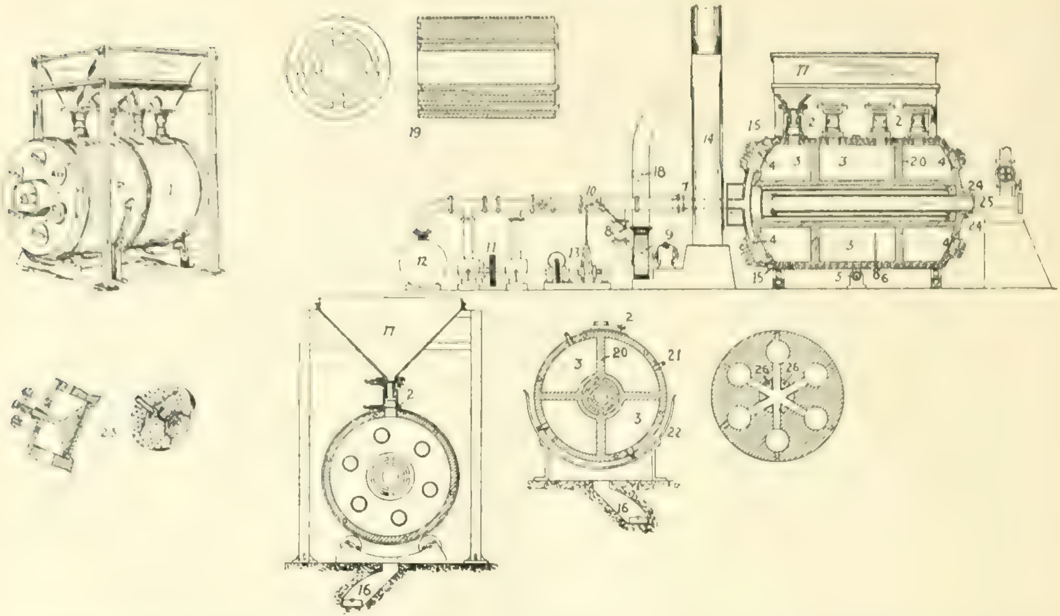


FIG. 1.—REVOLVING ROASTING FURNACE FOR CORBOULD'S PROCESS.

1.—Furnace. 2.—Charging gates. 3.—Roasting chamber. 4.—Filter boxes. 5.—Worm drive. 6.—Pyrometer. 7.—Stuffing box. 8.—Exhaust valve. 9.—Exhaust fan. 10.—Pressure valve. 11.—Blower. 12.—Air receiver. 13.—Variable cam gear. 14.—Flue. 15.—Non-return valves for air pressure to advance to fitters and check exhaust being drawn. 16.—Tunnel and drag conveyer. 17.—Charge bin. 18.—By-pass for SO_2 gas. 19.—Section of re-inforced moulded radiating tubes—moulded in short lengths laced on 12 steel rods—full length of roasting furnace. As each section is placed in position slag-sand concrete under pressure forced in holes to fill space between steel rods and walls of holes. Inside tube lined chrome brick. 20.—Supporting struts for radiating tubes. 21.—Safety valves. 22.—Guide ring rendering safety valves inoperative in down position. 23.—Section of porous fitters. 24.—Fuel gas cleaning plugs. 25.—Gas burner. 26.—Ports for conveying waste gas from radiating tubes to stack.

thereby producing sufficient free sulphuric acid in solution for the next charge of calcine and further requirements.

(4) Partial purification of the remaining mother liquor, together with the first wash solutions and precipitation of the copper content as hydrate by milk of lime.

(5) Dissolution of the copper in the hydrate precipitate by means of a solution of ammonia, followed by distillation of the ammonia liquor, producing pure copper oxide, and recovering the ammonia by condensation.

(6) Reduction of copper oxide to metallic copper.

(7) Treatment of the residue from (5) for the production of a by-product and the recovery of any remaining copper.

(8) Treatment of the washed slime residues from the ore charge for gold and silver by the cyanide process.

(9) Use of producer gas for the whole of the metallurgical operation as heating gas and to provide sulphate of ammonia.

The dried ore is crushed to 1 in. size, and then ground to 30 mesh.

As regards roasting, the essential requirements, temperature control and large capacity, demand a radical departure from existing types, and to obtain them the furnace shown in Fig. 1 was evolved. In the operation of this furnace the ore charge is subjected to heat by radiation and conduction through the internal tube system, and at the same time to alternate pressure and exhaust through the filter-boxes. The Corliss-type gear is so arranged that a rapid change from pressure to exhaust or change of ratio of duration of pressure and exhaust can be effected by means of the adjustable duplicate cams. This arrangement has great advantages in heating up the charge to the reaction temperature (about 560° C.) without the danger of over-roasting, and allows the charge to be maintained at the correct temperature during the time necessary to complete the catalytic action. During the first stage of the roasting the valves may be set to produce a gas rich in sulphur dioxide, which will be compressed and stored for use in a later stage. When sufficient gas has been thus obtained, the cams may be quickly adjusted while the furnace is in motion to introduce more air.

The furnace is heated by gas as shown, and the products of combustion pass forward and back along the internal tubes, thence by further pipes along the wall of the furnace and finally to the stack. This arrangement allows of a high temperature at the point of combustion without overheating the ore bed. The air delivered to the ore charge is pre-heated by passing through the stack, thus further utilizing the waste heat of the combustion gases. In operation, the furnace is charged about half-full and revolved at a speed of a quarter to half a revolution per minute. The completion of the roast is ascertained by withdrawing samples of the charge from conveniently arranged plugs, and making a simple test of the amount of water-soluble copper. The finished charge is released by turning down the furnace over the tunnel provided with a flight conveyor and opening the discharge gates.

The hot calcine passes to the cone mixer, to which is simultaneously added sufficient sulphuric acid solution to form a 1 to 1 pulp for the dissolving

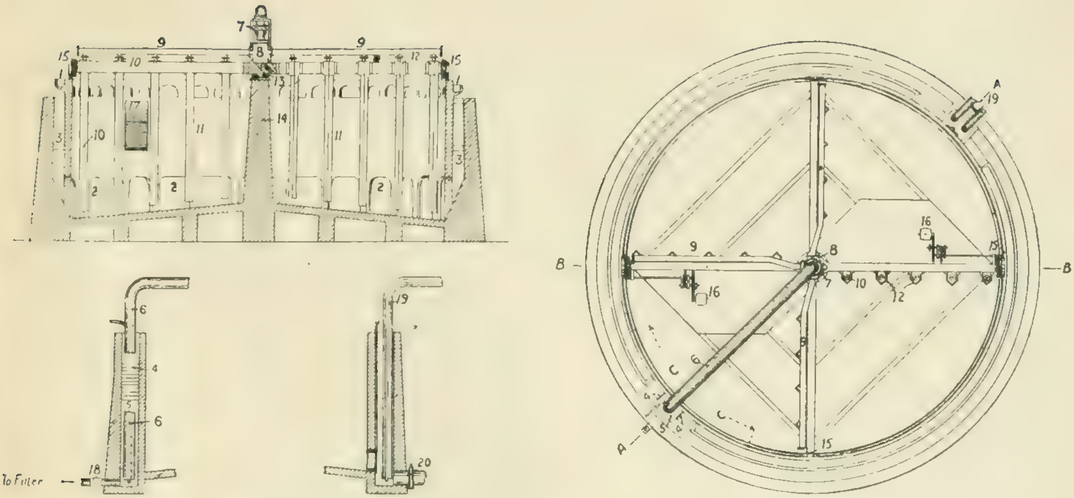


FIG. 2. -DISSOLVING AND WASHING PLANTS FOR CORBOULD'S PROCESS.

tanks. For an ore containing 5% copper, the stock solution made up from by-passed electrolyte will contain about 3·5% free H_2SO_4 (100%) and about 1% Cu. Fig. 2 shows the dissolving tank. The tank is charged through the launder (1) arranged to distribute pulp evenly round the tank. Light slimy liquors or wash waters flow under arches (2) through sand into the annular compartment (3) and over adjustable sills (4) into circulating box compartment (5), and are forced up by an air lift (6) through the acid-proof stuffing box (7) and four-way piece (8), thence along pipes (9) to vertical pipes (10) in wooden vertical agitating arms (11), and from thence the cycle is repeated. Agitating arms (11) are held in cast-steel sockets (12) fastened to the revolving girder-frame, supported in the centre on ball-bearings (13) mounted on the central pillar (14). The outer periphery of the revolving frame is supported on wheels (15) running on a circular rail round the top of the tank. Two wheels are geared to electric motors (16). After the driving motors have been stopped, mother liquor or various slimy wash solutions flow to box compartment (5) for slimes from annular compartments (3) to be sent back to the dissolving tank. Air is then shut off, and the liquor in the tank allowed to settle, which settled liquor is now drawn off over two central adjustable sills (17) into the annular compartments (3) to flow into box compartments (5) thence through cock (18) to filter to clarify liquor. In discharging, air lifts (19) are in duplicate. The pulp from the air lifts goes to a cone settler to denude it of coarse sand. The overflow from the settler goes to a Dorr thickener. The overflow from the thickener gravitates back to the dissolving tank to provide water to complete the emptying of the tank. The last water in the tank is discharged through the sluice-valve (20).

Air, preheated by waste heat from furnaces or gas coolers, is used in the air lifts. Copper sulphate and oxide being much more soluble in hot solutions than in cold, the utilization of heat in this way causes a great reduction in the time of contact necessary. All wash solutions go to separate tanks, the second wash solution becoming the first wash for the following charge, and so on, with the exception of the solution required for the gas plant. Clean water is used for the final wash, and owing to the use of milk of lime precipitating the copper from solution, a most efficient washing of the residues may be conducted, which in other methods would be impossible on account of the accumulation of a large tonnage of solution too low in copper to be utilized profitably.

The quantity of mother liquor taken for separate treatment is calculated so that the amount of copper contained will provide by electrolysis only sufficient free H_2SO_4 for the following purposes :—

(*a*) To dissolve the acid-soluble copper in the ore charge.

(*b*) To react with all the acid-consuming minerals such as the carbonates of lime and magnesia which remain unaltered after a sulphatizing roast.

(*c*) To acidulate the following mother liquor after neutralizing the purifying, before sending it to the electrolytic tanks.

(*d*) To dissolve the small percentage of copper and iron remaining in the $CaSO_4$ residue from the ammonia treatment.

The liquor, as calculated for the above requirements, is run to a special cone-bottomed vat and subjected to thorough oxidation by compressed air. Very finely divided (slimed) carbonate of lime is gradually added, only sufficient in total quantity to neutralize the free H_2SO_4 and precipitate the greater proportion of the iron or other impurities. The precipitate is filtered off and washed in an acid filter press, the filtrate being returned to the same vat and the washings sent to the main wash-solution storage-vats. The residue is treated later and marketed as a fertilizer.

Agitation is recommenced in the same vat, the temperature maintained, and according to the iron remaining in solution, a calculated amount of pure CuO from the ammonia process is added, precipitating the iron after the well-known reaction of Hofman. The residue is filtered off and washed as before, but in this case it is returned to the furnace bins for roasting with the next ore-charge, the iron of the residue remaining insoluble and the copper being recovered in the dissolving tank.

The purified solution of $CuSO_4$ is now acidulated by means of by-passed electrolyte to the extent of 1% free H_2SO_4 and is sent to the electrolytic

tank house. Electrolysis is conducted with a current of 12 amperes per sq. ft. of cathode surface, the anodes being of graphite and with arrangements for introducing SO_2 gas under pressure into the electrolyte for depolarization. In the presence of SO_2 the electrolysis of $CuSO_4$ solution results in the production of 2·3 lb. of free H_2SO_4 per lb. of copper deposited. Using this factor (2·3), the amount of free acid to be produced is calculated in advance, all electrolyte being by-passed from the tank house with a copper content of 2%. On account of the iron in the electrolyte being maintained below 0·2% (20 gm. per litre), it is possible to use graphite anodes yielding about 3 lb. of copper per kw. hour with a current density of 12 amperes per sq. ft. Current efficiency is thus kept high, a most important consideration where power is expensive.

The first wash solutions, together with the remaining portion of the mother liquor, go to a similar cone vat where they are given the same treatment with air and carbonate of lime for neutralization and partial precipitation of the iron or impurities. After the residue is filtered out and washed as before, the warm solution is agitated with gradual additions of milk of lime to produce as near as possible a selective action, that is, to precipitate most of the remaining iron with very little copper. The precipitate from this treatment is filtered off, the filtrate returned to the vat and the residue sent to the furnace bins with the next ore-charge. Further milk of lime is added, until all the copper is precipitated as hydrate, which readily settles and filters in a warm solution. On filtering the clear solution is utilized to make up the stock solution for the following roasted ore-charge by diluting the calculated quantity of acid electrolyte by-passed from the tank house.

The filtered residue, a concentrate of all the copper of the above solutions in the form of hydrate together with $CaSO_4$ and a little iron is immediately transferred to a sealed agitation vat and agitated with a solution of ammonia. The ammonia solution of a strength slightly in excess of two parts of NH_3 (100%) to one part of copper by weight, rapidly dissolves the copper hydrate, and on completion of the dissolution, the pulp is forced through a filter-press, the filtrate passing to a steam-jacketed still. The first washings of weaker ammonia solution are also passed to the still, and subsequent ores are stored for use on the next charge. All these operations are conducted in an ammonia-tight system, the storage vats for the weaker washings being arranged so as to be hermetically sealed. The treatment in the still consists simply in forcing steam into the copper-ammonia solution and condensing the ammonia driven off, the still being heated by steam in the jacket. The distillate is stored in steel tanks for the following charge. When complete elimination of the ammonia is effected, the steam is shut off, the precipitate allowed to settle and the clear solution decanted through a filter to the coolers at the gas plant, where the $CaSO_4$ in solution is concentrated. On the solution becoming saturated the $CaSO_4$ drops out, is recovered, and converted to pure plaster of Paris. Any ammonium sulphate in solution is similarly recovered.

The settled precipitate of CuO is washed by decantation and the amount required for the purification of the mother liquor for electrolyte is withdrawn to storage. The remainder of the CuO is conveyed to a small revolving furnace similar to the roasting furnace, where it is heated in an atmosphere of water gas. The reduced material is conveyed to a melting furnace where the metal is fused, poled, and cast into ingots as best selected copper. This method of reduction obviates the production of a quantity of high-grade copper slag.

The washed residue from the ammonia treatment is discharged to a mixer and sufficient by-passed electrolyte is added to dissolve the contained iron and copper hydrates and convert the little ammonia still remaining into sulphate. The pulp is filtered and the residue of $CaSO_4$ is washed and treated with previous $CaSO_4$ residues for the manufacture of fertilizer. The filtrate and washes are treated selectively with milk of lime to eliminate iron. The precipitate resulting is returned to the furnace with the next ore-charge. A portion of the solution is now passed through the ammonia absorbers of the producer gas plant. The NH_3 of the water gas combines with the $CuSO_4$ in solution, producing the characteristic azure-blue colour. On transferring this blue solution back to the remaining portion of treated solution, the copper in both portions is immediately thrown down as hydrate, which is filtered off, dried, and conveyed to the reducing furnace to be converted to metal by water-gas. The filtrate is now concentrated to recover ammonium sulphate, a portion of which product is heated with lime to obtain ammonia. Purified weak wash solutions from the dissolving tank are given a similar treatment to the above when required to absorb the balance of NH_3 produced from the coal. Any excess of ammonium sulphate above that required to make up the waste of ammonia in the process is disposed of as fertilizer with the $CaSO_4$.

In most cases the precious metals in the ore are combined with the copper minerals, and after the extraction of the copper, the gold and silver concentrate in the slime. On agitating this slime with cyanide the precious metals are extracted together with some copper, of which there remains about 0·3% in the tailing.

To start up operations a special charge is roasted and the water-soluble copper extracted. After purifying the liquor obtained, a small quantity of purchased acid is required for the necessary acidulation and the subsequent electrolysis will provide free acid for the future operation of the plant. The ammonia required will have to be procured until the producer gas plant is in operation, after which the losses to be made up will be no more than in good freezing plant practice. Water consumption will be the amount of moisture discharged with the residues, the amount evaporated, and the waste steam of the power plant not condensed, including that required in the producer plant. Solutions after treatment with milk of lime are perfectly free of copper. The $CaSO_4$ formed in the hot solutions causes no trouble in pipe lines. Throughout the process all solids filter readily. Reagents are regenerated or converted to by-products. There are no foul solutions, no solutions are discarded, and no copper is tied up in unfinished products. The process is a chemical one, and each step may be calculated chemically. If excess $CaCO_3$ be used to purify solutions, the excess will be coated with an oxide of copper. Coarse $CaCO_3$ has little or no action in purifying. Milk of lime should be as free as possible of $CaCO_3$. Solutions of $CuSO_4$ should be warm, not boiling, when under

treatment. Milk of lime should be gradually added, otherwise precipitation is impeded and excess of lime precipitate is accumulated. Copper hydrate precipitate should not be kept too long before treatment. Ammonia solution for dissolving should be about 20% NH_3 and only the final wash for the residue from the ammonia treatment should be clean water. Previous washes should all be weak ammonia solutions, otherwise Cu is precipitated out of solution. As power is expensive at most mines, it is much cheaper to produce electrolytic copper from a portion only of the liquors as required to produce the necessary H_2SO_4, and to convert the excess copper in solution to oxide, thence to metal, than to electrolyse the whole of the solutions from the ore charge.

Petrol from Natural Gas.—In his paper, read before the Institution of Petroleum Technologists on November 8, A. Beeby Thompson reviewed the question of prevention of waste in oilfields, and mentioned a great variety of ways in which waste may be eliminated. One of his points, well known to American oil-men, but usually neglected elsewhere, was that petrol or gasoline can be recovered from the gas coming from the oil-wells. We quote herewith Mr. Beeby Thompson's reminder on this subject :—

There are few oilfields which do not yield gases containing hydrocarbons that can be recovered by absorption or condensed to a liquid form by compression, refrigeration, or both. During the early career of oilfields the gaseous products may be very largely methane, but there is usually also a portion of the higher homologues of the paraffin series, and their proportion increases with the development of the field. The largest amount of condensable hydrocarbons are present where a partial vacuum is applied to the wells, that is, when a field is approaching exhaustion. Subjected to pressure or refrigeration, or both, hydrocarbons whose boiling points fall below the temperatures and pressures applied are liquified, and on exposure to atmospheric conditions they do not entirely revert to the gaseous form. Generally on liberation from the high-pressure condenser they boil, and the losses may be considerable, but if the lighter fractions are allowed to escape slowly without too violent agitation of the mass a varying quantity of a fairly stable product remains. The weathering of gasoline products extracted by pressure is, however, a wasteful procedure, as with some gases the greater part may spontaneously volatilize, leaving but a small fraction of that produced. It is by blending with heavier refinery distillates that the condensates of gas plants can most economically be retained and marketed. Mixed in suitable proportions with heavier gasolines they will lighten the gravity and not raise the vapour tension of the whole beyond that dictated by caution or permitted by law. The rising price of gasoline in the United States has caused those casing-head gases rich in gasoline to become a valuable and most sought for commodity, and high prices have been paid for installations that had secured gas rights over large areas at low rates.

The usual compression plants consist of compound compressor units of 200,000 to 5,000,000 cubic feet per day at 150 to 300 lb. pressure, either direct or belt driven from gas engines using some of the treated gas. The compressed product is passed through a water-cooled condenser from which the condensate is automatically trapped, while the escaping dry gas, after being expanded in a chamber forming the last section of the cooler, is led away for fuel requirements. Only careful consideration of each individual case will make it possible to say what gasoline contents can be made payable in any particular area, as it depends upon the cost of collection or purchase of gas, facilities for blending and transporting the desired products, the cost of installing the plant, and the uses for residual gas. Rarely can compressor plants be profitably operated with gas containing less than one gallon of gasoline per 1,000 cubic feet.

Some gases containing sulphur products cause such rapid corrosion of the valves and cylinders that the use of compressors is impossible, and at other times large percentages of carbon dioxide or nitrogen or of air, in the case of air propulsion, may render compression unprofitable even if the gas contains heavy hydrocarbon vapours. Such factors as the foregoing, together with the impossibility of profitably treating low-grade gases, led to the introduction of absorption processes which are now displacing the compression and refrigeration types. Most absorption processes rely upon the absorptive properties of certain petroleum distillates for lighter hydrocarbons, which later can be expelled by heating, and the recovered absorbent after cooling used over and over again ; indeed, a continuous cycle can be maintained of absorbing, expelling, and returning the chilled absorbent.

By means of absorption, gases can be profitably treated under favourable circumstances with contents as low as 1 pint per 1,000 cubic feet. Inflowing gas under as high a pressure as possible is allowed to meet a descending flow of suitable absorbent in vertical towers where convenient baffling is interposed to ensure intimate contact of the two fluids. The liquid from the towers is conducted to a still, where, during passage through a series of chambers, its light contents are expelled by heat, and the freed absorbent is returned to the towers, being subjected to cooling in its progress. By counter-flow arrangements the outflowing hot liquid is made to heat up the inflowing absorbent. Even with this process the gasoline is often wild, and unless somewhat intricate complications are included that provide for the condensation and return to the circuit of products evolved on release of pressure much light-density petrol is lost. The process does, however, appear to yield a more stable product than compression, and varying methods of absorption undoubtedly influence the quality of the product.

One step further has now been reached by the discoveries of Messrs. Burrell & Oberfell, who, by using " activated " charcoal as an absorbent, are able to obtain a much larger proportion of stable gasoline products than by any other process, larger, indeed, than that theoretically attainable by past recognized methods of testing. A condensation of carbon molecules has been suggested, but it is likely that the difference is due to mechanical features. This recent development opens up a new line of study that may influence the future of this industry.

As already stated, at present practically no treatment of gas for gasoline contents has been undertaken on a large scale outside America. In 1919 no less than 300,000,000 gallons of casing-head gasoline was produced in the United States,

being about 13% of the total gasoline production, although only a part of the gas available had been so far treated. The value of this gasoline constituted much more than the 13% of the total United States gasoline values, which later were estimated at 45% of the value of all American produced oil products in 1919, although its quantity represented but 25% of the crude produced.

From numerous tests made it is clear that the gaseous emanations of most oilfields contain products that would well repay their extraction, provided there were convenient means for their disposal, and it is this latter feature, which has probably been one of the chief hindrances to obvious savings that are annually being accentuated by the rising prices of petrol.

Occurrence and Origin of Helium.—Professional Paper No. 121, issued by the United States Geological Survey, and written by G. Sherburne Rogers, is the most complete monograph on helium yet published. It gives a detailed review of the history of the discovery of this gas, with full references, and it contains also the results of the author's studies of the occurrence of helium in natural gas. The author's brief résumé of the occurrences and theories as to origin are reproduced herewith.

Helium constitutes from 0·5 to 2% of certain nitrogen-rich natural gases in Kansas, Oklahoma, and Texas, and occurs in smaller proportions in the gases of many other districts in the United States. The gases richest in helium are confined to strata of upper and middle Pennsylvanian age and occur close to the surface, the helium content usually decreasing with increasing depth. Gases containing from 0·25 to 0·5% of helium occur in the lower Pennsylvanian (Carboniferous) of the Mid-Continent area, in the Mississippian and Silurian of Ohio, and in the Cretaceous of Montana, although in general the pre-Pennsylvanian gases are poor in helium, and the Cretaceous and Tertiary gases carry only traces or none at all. The helium-rich areas are not marked by igneous activity or by unusual structural conditions. There is no evidence as to whether or not the rocks in these districts are abnormally radio-active.

Helium has been detected in European natural gas in proportions as great as 0·38%. The richest gas was found in a deep test-hole in Alsace, probably in lower Mesozoic strata ; the Tertiary gas in this locality is very poor in helium and the Tertiary gases of Germany, Austria, Italy, and Transylvania are also poor. The helium content of these gases appears to vary roughly as their radio-activity.

A great variety of minerals have been found to contain at least traces of helium, and apparently only a few species are helium-free. Minerals rich in the radio-elements may contain several times their own volume of helium ; ordinary rock-forming minerals are usually poor. In general the amount of helium in a mineral is proportional to its radio-activity and increases with age, indicating that the helium has been generated by the decay of the radio-elements ; but certain beryls contain far more helium than can be explained in this way.

The gases of French and Belgian coal mines carry helium, and though the proportion is small the total volume emitted yearly is large. The coals themselves are very poor in the radio-elements, and helium is evidently not being generated in the coal nearly as fast as it is being emitted. There is, therefore, no evidence to connect the helium in the mine gases with radio-activity.

The gases of many European mineral springs contain helium in proportions as great as 10%. The volumes of helium emitted yearly by some of the springs represent all the helium that would be generated yearly by many tons of radium : hence this helium like that in mine gases, probably represents the overflow or leakage of a great underground accumulation. Furthermore, the proportion of helium in the gases bears no relation to their radio-activity.

Small proportions of helium occur in the gases of certain Italian fumaroles, where there is no evidence to connect it directly with radio-activity.

Helium constitutes 0·0004% of the atmosphere near the earth's surface. In the upper atmosphere its proportion is greater.

Helium is a prominent constituent of the solar chromosphere and of many nebulæ and stars, though the radio-elements have not been identified with certainty in any celestial bodies.

As the radio-elements generate helium in the course of their spontaneous disintegration, each occurrence of radio-active material connotes the presence of helium ; but the radio-elements, because of their activity, can be detected in far smaller quantities than can the helium to which they give rise. The radio-elements are very widely disseminated through terrestrial materials, being present in minute proportions in practically all minerals and rocks, in the atmosphere and in river and ocean water. Most petroleum and natural gas apparently contain some radium emanation. The helium generated by the radio-elements disseminated through ordinary rocks amounts to almost half a cubic foot per year per cubic mile of rock.

From the foregoing evidence certain broad conclusions may be drawn as follows :—

The helium in most minerals is probably of radio-active origin ; and, as the radio-elements are disseminated through ordinary rocks in proportions sufficient to generate large volumes of helium in the course of a few million years, much of the helium in rocks has probably also originated through radio-activity.

As helium is very prominent in celestial bodies, whereas the radio-elements are not, it is probable that helium can and does occur in the universe entirely apart from the radio-elements, and that these elements may be regarded as compounds of helium and lead which form only under certain conditions. Accordingly, much of the helium in the earth may never have been associated with the radio-elements and may therefore be primordial helium.

As the volumes of helium in some mineral-spring and mine gases are so large that incredible quantities of the radio-elements would be necessary to generate the helium as fast as it is emitted, it is probable that there are great stores of helium underground, the leakage or overflow of which appears in the spring and mine gases. These stores of "fossil" helium may be accumulations of the small volumes liberated by the disintegration of radio-elements through geologic time, or they may in large part be primordial. The helium in natural gas may therefore be primordial or it may have been liberated through the decay of the radio-elements. As a great volume of helium is contained in the atmosphere there is the third possibility—which is not concerned with the ultimate origin of the element—that the helium in natural gas has in some way been derived from the atmosphere.

Mining in British Guiana.—We extract the following paragraphs from the report of the Lands and Mines Department of British Guiana for the year 1920 :—

The output of gold for 1920 from all sources was 12,692 oz., of the value of £46,803, being a decrease of 3,524 oz. on the production for 1919. The decrease is due to the fact that fewer persons were engaged in the gold-mining industry than formerly owing to the high price of provisions, which rendered it more or less impracticable for the small claim holder and tributer to make a profit; also to the fact that the diggers who formerly worked gold were attracted to the diamond fields by the high price that ruled for precious stones during the early part of 1920. A number of men were also influenced to stay on the coast lands by the satisfactory rate of wages obtainable on the sugar estates and sea defence works.

An amount of 6,454 oz. was produced by placer washing, a decrease of 3,998 oz. on the production for 1919.

The Guiana Gold Company operated in the Konawaruk River with four dredges, and the Minnehaha Development Company operated with one dredge in the Mahdia Creek. The gold obtained by these two companies from dredging during the year was 6,238 oz., an increase of 1,001 oz. on the previous year's production. The Commissioner is of opinion that dredging is the most suitable method of winning gold from the larger creeks and flats with deep overburdens in the auriferous portions of the Colony. The substitution of a tax on profits in lieu of a royalty charge in the case of gold won by dredging will, it is confidently hoped, act as an incentive and, in time, when the financial slump at present existing throughout the world has passed away, mining capitalists will turn their attention to gold dredging and hydraulicking on a large scale in this Colony.

No quartz mining operation were carried out during the year. In No. 2 Mining District, however, explorations were carried out by the Minnehaha Development Company in the vicinity of "Look and Weep," Upper Minnehaha Creek, with a view of ascertaining whether the values of ore existing in that locality and the neighbourhood would warrant milling operations being carried out on a large scale. The result of such investigations were not made public by the end of the year.

During the year 234,456 diamonds, weighing 39,362 carats, of an estimated value of £211,829, were declared at the Department. Of these 144,348 stones weighing 25,898 carats were from the Mazaruni River; 54,404 diamonds weighing 9,444 carats were from the Puruni River; 22,386 diamonds weighing 2,738 carats were from the Cuyuni River, and 13,318 diamonds weighing 1,281 carats from the Potaro River. The notable features with regard to the year's production are the working of diamonds on the Potaro River, between Kangaruma and Amatuk, and the large increase in the total production for 1920, amounting to 149,990 stones weighing 22,656 carats over the output for 1919. These diamonds were all from alluvial workings and the entire output averaged six to the carat, but there were many stones of a carat and over. The sixteen largest stones presented at the Department during the year weighed respectively $21\frac{5}{16}$, $9\frac{13}{16}$, $9\frac{1}{4}$, $9\frac{1}{16}$, $8\frac{1}{2}$, $8\frac{1}{4}$, 8, $7\frac{1}{4}$, $6\frac{3}{8}$, $6\frac{1}{4}$, $5\frac{5}{16}$, $5\frac{1}{2}$, $5\frac{3}{16}$, $5\frac{1}{4}$, $5\frac{1}{4}$, $5\frac{1}{16}$ carats.

The Demerara Bauxite Company carried on mining operations at Akyma, Demerara River, throughout the year. The construction of the light railway from Akyma to Mackenzie and the erection of the crushing, washing, and drying plants at Mackenzie were completed during the year, all of which contributed to the more expeditious and economical handling of the ore. The total quantity of dehydrated ore shipped during the year was 31,379 tons.

Examinations for oil on behalf of D. E. Alves, of London, were made in the North-West District and other parts of the Colony by B. F. Macrorie and J. A. Bullbrook. Their results were not made public during the year, but it was generally understood that the opinion of the experts was unfavourable as to the occurrence of mineral oil in the Colony. It is, however, worthy of record that no prospecting bore-holes were put down and that this opinion is therefore based solely on the surface examinations made, coupled with the results of previous similar investigations by G. B. Reynolds, made in 1919.

Flotation for Rand Ores.—Interest in the application of flotation to Rand ores has been revived recently, and the paper by F. Wartenweiler, quoted in our September issue, has helped to draw attention to this subject. E. Homersham lately went to Johannesburg as representative of Minerals Separation, Ltd., and a laboratory has been opened there. Mr. Homersham gives some particulars of tests in the *South African Mining and Engineering Journal* for October 22.

(1) Crude ore from mine: Assay-value of ore, 9·9 dwt.; ore crushed to 80 mesh; value of concentrates, 65·9 dwt.; percentage of concentrate caught, 14·8; residues, 0·42 dwt.; recovery, 98·5%; cost of reagent, 7d. per ton.

(2) Slimes untreated: Assay-value of slimes, 1·34 dwt.; assay-value of concentrates caught, 7·2 dwt.; percentage of concentrates caught, 16·4%; residues, 0·20 dwt.; recovery, 88·1%; cost of reagent, 4d. per ton.

(3) Black Reef tailings; Assay of crude sample, 2·45 dwt.; assay-value of concentrates, 24·6 dwt.; percentage of concentrates caught, 8·6%; residues, 0·42 dwt.; recovery, 86·3%; cost of reagent, 8d. per ton.

(4) Sand residues from Rand ore: (1) The first tests were on sand as received without further grinding. There was no difficulty in concentrating by flotation the free mineral consisting of iron pyrites. The concentrates averaged 10 dwt. in value, and were about 6% of the bulk treated. The original value of sand in this test was 1·4 dwt. and the residues averaged 0·85 dwt. It was quite clear that a large proportion of gold was locked up in sands and could only be floated by further grinding. (2) The next test was made as follows: Assay of crude sand, 1·75 dwt.; concentrates, 12·6 dwt.; percentage of concentrates caught, 10·3; residues, 0·45 dwt.; recovery by flotation, 74·1%; crushing, 80 mesh; average cost of reagents 4d. per ton.

In view of the above results, even allowing for the cost of regrinding sand, it appears probable that these particular sand residues can be profitably retreated by flotation.

A fairly large scale test of 1,870 lb. run in London recently gave a 0·55 dwt. residue on a grade of ore assaying 22 dwt. If the ore had been of a lower grade, undoubtedly a far lower residue would have been obtained; as it is, this result indicates a recovery of from 96 to 98%. From tests done

in Johannesburg and in London it appears probable that on a 4 dwt. ore a residue of 0·15 to 0·2 dwt. may be looked for, the residue rising more or less slowly as higher grade ore is treated.

It is believed that the process, if applied to current reduction works, would mean a large saving in working costs. Instead of treating the whole of the crude ore by cyanide, it is believed from the results obtained up to date that a 10% concentrate can be obtained containing from 93 to 97% of the gold in the ore, and that this concentrate can be easily treated by the ordinary cyanide method.

Nickel Metallurgy.—The *Bulletin* of the Canadian Institute of Mining and Metallurgy for November contains two brief notes on points relating to the smelting of nickel-copper ores in the Sudbury district.

William Kent writes on a false chute for skimming converters used at the smelter of the International Nickel Company. With the large basic-lined copper-converters now in use, the common practice is to do all charging, skimming, and casting through the throat of the converter. Most of these converters are rotated by means of electrically operated worm gear, and it is possible to turn them through a complete revolution. The converters at the International Nickel Company's smelter, however, are turned by means of cables actuated by pistons in horizontal cylinders, and hence the extent of the rotation is limited by the stroke of the piston. Owing to this method of rotation, the skimming and casting have to be done through a chute at the side of the shell. The limited extent of the rotation also renders it necessary to have the opening through the shell, at this chute, about 30 in. high, in order to be able to carry the converter full of matte while blowing, and to be able to drain out the last of the finished matte when casting. Before charging the converter the opening in the shell is blocked up with magnesite brick to within about 6 in. of the top, the chute outside being filled with clay to the same height. A cake of clay covers the remaining opening during the blow and is removed when ready to skim. During the successive skims the slag running over the clay in the chutes permeates it and bakes it to such an extent that a very hard mass is formed. When ready to cast, about three-quarters of the matte is poured from the converter in the same way, tending to still further harden the clay. To drain out the final quarter of the matte, it is necessary to dig the clay out of the chute and remove the bricks from the lower part of the breast opening. The removal of the clay entailed a good deal of hard work with bars and hammers, and, in addition, caused considerable delay. All this is now obviated by the use of a false chute, which fits just inside the fixed chute and does not interfere with the regular procedure in any way. The false chute is provided with short chains at the corners, and when the time comes for the removal of the clay, the crane comes along and lifts out both chute and clay, leaving the breast exposed. It is then only necessary to remove the bricks and complete the casting. When cold the false chute is easily cleaned out and is again ready for use.

R. J. Gill read a paper on improvements to settlers at the British America Nickel Corporation's smelter at Nickleton. The settler practice at the British America smelter is somewhat unusual for the Sudbury district. A great portion of the matte is tapped from the settler by means of so-called syphons. The principle is similar to that of the Orford settler, or of the Watson settler. The last-named is a modification of the Orford used at the Ladysmith plant of the Tyee Copper Company. At Nickleton the 16 by 30 ft. settlers are lined with chrome brick. The floor is made up of three courses of chrome brick laid on 6 in. of fireclay. The top and bottom courses are laid on edge, and the intermediate course flat. The walls are three bricks thick, the outside row being firebrick. An additional row of chrome brick was added for part of the height of the wall, as the settler must always contain about 10 in. of matte. The front wall was also increased in thickness to about 22 in. The shell of the settler is ½ in. steel plate. Originally there were four matte tap-holes at the front and two slag overflow openings at the back. To convert the settler into a syphon settler a wall of chrome brick 15 in. thick was built across the settler, a little over 2 ft. from the front wall. A wall at right angles to this divided the portion thus cut off into two wells. For admitting the matte an opening approximately 24 in. wide by 8 in. high was left in each of these wells at the floor of the settler. Thus, so long as the matte level in the main settler is kept above the opening, no slag can enter the well. An opening was made in the front wall just deep enough to ensure that when the bath in the settler is raised by blocking the slag overflow, the matte will flow out of the well into a launder from the top of the settler. The flow of matte is stopped without difficulty by opening the slag overflow and letting the bath down. Two of the original tap-holes are retained, one from each well. Magnesite blocks, 8 by 8 by 8 in., are set in these, without a cooling jacket of any kind. They are held in place by cast-iron plates secured by wedges. All the matte drawn from the settler must pass through the openings into the bottom of the wells; but after several months of service the brick in the arch over the opening showed little sign of wear. Owing to the large quantity of matte and the inferior quality of the refractories at hand, it was extremely difficult to keep the tap-holes in good condition. This syphon was devised to overcome this trouble, and has been a complete success. The tap-holes are now kept open more for use in case of an emergency than for any other reason. The matte well shows no tendency to chill, due probably to the fact that it is contained in the settler; the only loss of heat by radiation is through the thick front wall.

Treatment of Zinc Residues. — *Chemical Engineering and Mining Review* (Melbourne) for August gives some particulars of the direct method of dissolving fume in acid adopted in the treatment of zinc residues at the works of the Electrolytic Zinc Company of Australia, Risdon, Tasmania. In the electrolytic method of treatment the concentrates are first roasted and then leached with sulphuric acid solution. The residue left after the leaching operation contains a certain amount of zinc, together with lead and other metals, and it has been customary to treat this residue for the formation of fume by mixing it with a reducing agent, such as coke, and subjecting the mixture to a blast of air on a Wetherill grate or some such suitable furnace. This fume is sometimes sold as a leaded zinc pigment, but is often leached with sulphuric acid to produce electrolytic zinc. The method of fuming as applied to the residue from the leaching operation has also been applied directly to the ore either roasted or unroasted. Various patents have been taken out for processes aiming at

the conversion of zinc into fume, and its collection therefrom. In 1904 (Commonwealth 264) J. C. Clancy proposed blowing sulphide ore into a highly heated chamber to transform the zinc sulphide into oxide, which would be condensed and leached out with H_2SO_4. In 1907 Hommel and Sulman (Commonwealth 10,362) patented an elaborate process in which the sulphide ore is roasted and mixed with coal and suitable fluxes, placed in a furnace on heated fuel, and air blown through. The zinc is recovered from the condensed fume by leaching with sulphuric acid. J. H. & P. M. Gillies (Commonwealth 171) in 1916 proposed to fume lead and zinc, leaching the zinc from the condensed fume with H_2SO_4. Another patent (Commonwealth 6,456) taken out in 1918 by the same investigators, related to a similar leaching process. Laist, of Anaconda, patented a combination leaching and smelting process for electrolytic zinc residues in 1917 (Commonwealth 6,018), in which the residues are dried, mixed with fine coal, and smelted to produce a matte, slag, and fume containing the lead and zinc, which is collected and leached with dilute H_2SO_4 for the recovery of the zinc. In all these methods, however, the expensive means of collection by bag-houses or electrical precipitation have been involved. In cases where it is subsequently intended to leach the fume, it would be a matter of great benefit if the above methods of treatment were modified so that in this fuming operation the bag-house or similar collecting means were replaced by a cheaper method. Experiments have accordingly been carried out by the Electrolytic Zinc Co., at Risdon, with a view to evolving a process by means of which the fume may be directly leached without the intervention of a bag-house or other collecting means. The resulting new treatment, which is proposed to be put into operation on a large scale, consists in passing fume from the Wetherill furnaces upward through a tower checkered with suitable packing to give a large area on contact and to prevent accumulations of the insoluble portion of the fume. Down this tower H_2SO_4 solution (spent electrolyte) is caused to flow against the ascent of the fume so as to be brought into intimate contact with them, causing the soluble constituents, which consist principally of zinc compounds, to be dissolved in the descending solution, which is run into a receptacle at the bottom of the tower. The solution and solid residue thus collected are treated by known metallurgical methods for the recovery of their valuable metal contents.

SHORT NOTICES

Rapidity of Boring. In the *Iron and Coal Trades' Review* for November 11, A. E. Ritchie gives comparisons between British, German, and American boring practice, exemplifying his points by reference to bore-holes in the Kent coalfield. British boring was too slow, and on the other hand, German boring was too rapid for securing satisfactory records of the strata passed through. The Sullivan Machinery Co., of Chicago, has done rapid work in this country, and though not quite so rapid as the German firms, gives better geological records.

Diamond - Drilling. In the *Colliery Guardian* for November 4, J. A. MacVicar gives some records of experience in boring in the United Kingdom by means of the Sullivan diamond-drill.

Ventilation at Broken Hill. — At the meeting of the Australasian Institute of Mining and Metallurgy, held in August, a paper was presented by R. T. Slee, describing the ventilation system at the Broken Hill Proprietary mine.

Acidity of Mine Waters. In a paper published in the September issue of the *Journal* of the Chemical, Metallurgical, and Mining Society of South Africa, F. W. Watson and R. A. Cooper revive the question of the neutralization of acids in mine waters.

Air-Lift for Tailings. In the *Engineering and Mining Journal* for November 19, H. G. S. Anderson describes the air-lift for raising tailing at the Chino copper mine, New Mexico.

Broken Hill South. — At the meeting of the Australasian Institute of Mining and Metallurgy held in August, W. E. Wainwright and J. C. Cunningham presented a paper describing the new concentration plant at the Broken Hill South mine.

Filter-Presses. The *Journal of Industrial and Engineering Chemistry* for November contains reports of a great many articles on filter-pressing practice presented at the meeting of the American Chemical Society held in September.

Chloridizing-Volatilization.—In the *Engineering and Mining Journal* for November 2, H. R. Layng gives some instructions for improvements in the methods of conducting the chloridizing volatilization process, in particular with the object of preventing accretions.

Sulphuric Acid.—In *Chemical and Metallurgical Engineering* for November 9, A. M. Fairlie commences a series of articles on modern improvements in the method of producing sulphuric acid.

Uranium Steel. In *Chemical and Metallurgical Engineering* for October 26, H. S. Foote discusses the properties imparted to steel by varying percentages of uranium.

Chromium Steel. In *Chemical and Metallurgical Engineering* for November 2, F. P. Zimmerli gives a historical bibliography of chromium steels. This bibliography gives a brief abstract of most of the entries.

Determination of Chromium. The *Journal of Industrial and Engineering Chemistry* for November contains an article by G. L. Kelly and J. A. Wiley on the determination of chromium in ferro-chromium by electrometric titration.

Radium. In *Chemical and Metallurgical Engineering* for November 2, H. D. d'Aguiar describes the method of producing radium compounds in America.

Cornish Geology.—The *Geological Magazine* for November contains a paper by E. H. Davison on the primary zones of Cornish lodes.

Grecian Magnesite.—In the *Engineering and Mining Journal* for November 12, H. C. Boydell gives an account of the magnesite deposits in the island of Eubœa, Greece.

Tin in Queensland. The *Queensland Government Mining Journal* for September contains a report by E. C. Saint-Smith, Government Geologist, on the Ewan Tin Syndicate's properties in the Kangaroo Hills district.

Uganda. — The *Geographical Journal* for November contains an account of the Lake Albert Rift Valley, Uganda, by E. J. Wayland, Government Geologist.

Low-Temperature Carbonization. The *Iron and Coal Trades Review* for November 11 publishes a report made by Sir Percy Girouard on the process

[illegible] plant of the Low Temperature Carbonization Co., Ltd., at Barnsley, the present company that [illegible]

Coalite. *Engineering* for October 28 gives an illustrated description of the plant of Low Temperature Carbonization, Ltd., at Barnsley, which makes coalite and various by-products.

Venezuelan Petroleum. The *Engineering and Mining Journal* for November 12 publishes an official report by A. H. Redfield on the petroleum industry of Venezuela during the year 1920.

Colorado Shale Oils. In *Chemical and Metallurgical Engineering* for October 19 and 26, A. J. Frank gives an account of the oils obtainable from Colorado shales.

Gas from Wood Refuse. The *Engineer* for November 18 describes a gas producer designed for using waste wood, made by Ruston & Hornsby, Ltd., of Lincoln.

C. W. Purington. The *Engineering and Mining Journal* for November 5 gives a brief biography of C. W. Purington.

Alfred James.—The *Engineering and Mining Journal* for November 19 contains a biographical notice of Alfred James.

RECENT PATENTS PUBLISHED

☛ *A copy of the specification of any of the patents mentioned in this column can be obtained by sending 1s. to the Patent Office, Southampton Buildings, Chancery Lane, London, W.C. 2, with a note of the number and year of the patent.*

6,921 of 1920 (169,467). CHEMISCHE FABRIK RHENANIA, Aachen, Germany. Method of recovering sulphur from sulphuretted hydrogen.

10,078 of 1920 (169,473). J. & A. ROSS, Uddington, Scotland. Signalling apparatus for mines.

10,293 of 1920 (170,026). C. E. CORNELIUS, Stockholm. Furnace for treating zinc dust for the production of spelter.

16,587 of 1920 (169,764). E. E. NAEF, Nottingham. In the manufacture of copper the treatment of finely divided copper sulphides with solid caustic soda or potash, or mixtures thereof with any or all of the following: sodium carbonate, common salt, sodium sulphate, sodium sulphide, calcium oxide and hydroxide, at temperatures generally from 300° to 800° C., with or without the addition of finely divided coal, or in presence of hydrogen and gases containing such, or in presence of both coal and hydrogen.

18,669 of 1920 (146,814). MASCHINENFABRIK WESTFALIA, Gelsenkirchen, Germany. A channelling rod for mining machines of the rod type.

18,979 of 1920 (147,030). E. H. WESTLING, San Francisco. Method for producing pure manganese dioxide.

19,253 of 1920 (147,186). P. SCHERMULY, Frankfurt-am-Main, Germany. A new form of divining rod.

19,363 of 1920 (147,457). AMPERE GESELLSCHAFT, Berlin. Method of producing a tungsten-iron alloy used in the jewellery trade.

19,364 of 1920 (147,458). AMPERE GESELLSCHAFT, Berlin. Method of producing ferrochromium low in carbon.

19,755 of 1920 (147,752). W. P. THOMPSON, Liverpool. Method of making white lead.

19,959 of 1920 (170,082). METALLBANK and METALLURGISCHE GESELLSCHAFT, Frankfurt-am-Main, Germany. Method of producing zinc oxide by precipitation from sulphate solutions sufficiently free from sulphate of lime to make it suitable for smelting for zinc.

20,248 of 1920 (148,334). M. SCHLÖTTER, Berlin. An electroplating process for producing a firmly adhering deposit of tin.

20,522 of 1920 (148,539). SPRENGLUFT GESELLSCHAFT, Charlottenburg, Germany. Method of making cartridges of carbonaceous matter suitable for absorbing liquid air, to be used for blasting purposes.

20,526 of 1920 (148,543). A. R. AHRENDT & Co., Berlin. Apparatus for producing a respirable air from liquid air.

20,518 of 1920 (148,535). C. A. BALDUS and A. KOWASTCH, Charlottenburg, Germany. Fuses for igniting blasting cartridges in which liquid aid is used.

20,525 of 1920 (148,542). P. MEFFERT, Coblenz, Germany. Improved receptacles for holding blasting cartridges containing liquid air.

20,885 of 1920 (170,100). L. H. DIEHL, Darmstadt, Germany. The treatment of material containing iron and zinc in a blast-furnace, so as to recover the zinc by volatilization and the iron by reduction and melting.

21,787 of 1920 (170,404). L. A. LEVY and R. H. DAVIS, London. A respirator useful in atmospheres containing carbonic oxide.

21,988 of 1920 (170,651). W. E. NETTLE, P. SELBY, J. BLYTHE, and J. H. HOLMAN, Johannesburg. Mechanism for supplying water to rock-drills.

25,892 of 1920 (170,474). BADISCHE ANILIN & SODA FABRIK, Ludwigshafen am Rhein. A fertilizer consisting of ammonium sulphate and ammonium nitrate. [This mixture is said to be explosive and to have caused the disaster at Oppau.]

29,801 of 1920 (163,023). RHENISCH-NASSAUISCHE BERGWERKS UND HÜTTEN GESELLSCHAFT, Stolberg, Rhineland, Germany. Improved methods of rabbling in Spirlet roasting furnaces.

13,621 of 1921 (164,725). SOCIÉTÉ D'ELECTRO-CHIMIE ET D'ELECTRO-METALLURGIQUE, Paris. Improvements in the electrolytic method of producing iron.

NEW BOOKS, PAMPHLETS, Etc.

☛ Copies of the books, etc., mentioned below can be obtained through the Technical Bookshop of *The Mining Magazine*, 724, Salisbury House, London Wall, E.C. 2.

Catalogue of British Scientific and Technical Books. Prepared by a Committee of the British Science Guild. Cloth, octavo, 390 pages. Price 10s. net. London: The British Science Guild, 6, John Street, Adelphi, London, W.C. 2. This is an ambitious work, but covers far too much ground, ranging from dermatology and aeronautics to textiles and tobacco culture. Then, again, a catalogue is of no use to English readers unless it includes American books. The classification is by no means perfect, and the preface acknowledges this difficulty; but we did not expect to find Julian and Smart's Cyaniding Gold and Silver Ores under the heading of ore-dressing.

Preliminary Report on Petroleum in Alaska. By G. C. MARTIN. Bulletin 719 of the United States Geological Survey.

Mineral Industry of the British Empire: Phosphates. Pamphlet. 70 pages. Price 2s. net. London: Imperial Mineral Resources Bureau.

Geology and Mineral Resources of the Serb-Croat-Slovene State. By D. A. WRAY. Foolscap, paper covers, 110 pages, with maps and other illustrations. Price 3s. 6d. net. London: The Department of Overseas Trade. This is a report prepared for the British Economic Mission to Serbia, by a member of the Geological Survey of Great Britain.

Practical Chemistry of Coal. By A. E. FINDLEY and R. WIGGINGTON. Cloth, octavo, 150 pages, illustrated. Price 12s. 6d. London: Benn Brothers, Ltd.

Geological Survey of West Australia. Bulletin 79: Mining Geology of Comet Vale and Goongarrie, by J. T. JUTSON; Bulletin 80: Mining Centres of Quinn's and Jasper Hill, by F. R. FELDTMANN; Bulletin 81: The Warriedar Gold-Mining Centre, by F. R. FELDTMANN.

Permeation of Oxygen Breathing Apparatus by Gases and Vapours. By A. C. FIELDNER, S. H. KATZ, and S. P. KINNEY. Technical Paper 272 of the United States Bureau of Mines.

Miners' Consumption in the Mines of Butte, Montana. By D. HARRINGTON and A. J. LANZA. Technical Paper 260 of the United States Bureau of Mines.

Relative Safety of Brass, Copper, and Steel Gauzes in Miners' Flame Safety Lamps. By L. C. ILSLEY and A. B. HOOKER. Technical Paper 228 of the United States Bureau of Mines.

Income Tax Guide, 1921. By H. W. PALMER. Price 1s. net. London: *The Financial Times.* The incidence of the income tax does not become any the less inexplicable, nor does the tax itself grow any less burdensome, and we should be grateful to those who try to help us to bear and to understand one of the most serious of life's many troubles. The management of the *Financial Times* have produced a new and revised edition of their *Income Tax Guide*, which tells us all about income, excess profits, and corporation taxes, what to pay, and how to obtain relief, with tables and examples. The booklet is based throughout on official data, is thoroughly up to date, and is so written that it may be understood even by those to whom the mere mention of income tax involves an immediate and dermanent clouding of the brain.

COMPANY REPORTS

Weardale Lead.—This company has been working lead mines in Weardale, County Durham, since 1883. The control is in Newcastle-on-Tyne, Professor Henry Louis is consulting engineer, and H. S. Willis is manager. The report for the year ended September 30 shows that owing to the fall in the price of lead it became necessary to restrict operations to the more profitable places. In addition, the mines were entirely idle for twelve weeks owing to the coal strike. The output of lead concentrate was 1,563 tons, and of fluor-spar 6,870 tons, comparing with 2,774 tons and 9,374 tons during the previous year. The accounts show a loss of £10,828 on working account, and £8,229 has to be provided for income tax. On the other hand, £8,821 previously paid as excess profits duty has been recovered. The year began with a credit balance of £4,005, and £2,936 was received as dividends on investments. The year ended with a deficit of £3,286. The question of wages has been frequently discussed with the men, and the latter have agreed to reductions in keeping with the general state of the labour market. Some substantial economies have been effected by the installation of electric haulage and new dressing plant. These two facts encourage the directors in the belief that profits will be made once more in the early future.

Burma Corporation.—The history of the various companies that have successively operated the lead-zinc-copper-silver deposits at Bawdwin, Northern Shan States, are already sufficiently well known, so that no reference to earlier reports is necessary here. Suffice it to say that the property was transferred in December, 1919, to a company registered in Rangoon. The report now issued by this company covers the year ended December, 1920. During this period 93,038 tons of ore, averaging 38·1% lead, 23·6% zinc, 0·4% copper, and 37·3 oz. silver per ton, was sent to the smelter; and 30,424 tons, averaging 33·8% lead, 24·5% zinc, 0·2% copper, and 31·7 oz. silver, was sent to the concentrators for the separation of the sulphides. The first unit of the water-concentration plant was started in July, 1920, but owing to the scarcity of suitable labour only a few machines were started at a time. In fact the work throughout the year was in the nature of training labour. The flotation plant was not started until 1921. During 1920 the smelter treated 136,450 tons of material, averaging 29·57%, 15·5% zinc, and 26·72 oz. silver per ton, and 28,484 tons of lead bullion was produced. The refinery produced 23,821 tons of lead and 2,869,727 oz. of silver. The reserve is estimated at 4,429,458 tons, averaging 25·3% lead, 17·7% zinc, and 23·2 oz. silver per ton; of this total 335,681 tons is copper ore averaging 11% copper, 12·8% lead, 7·7% zinc, and 23·2 oz. silver. Owing to the depressed position of the metal market, it has not been possible to proceed with various expansions contemplated, and it has been necessary to continue the policy of obtaining an income by the treatment of the sections of ore richest in lead and silver. The contemplated yearly output is 45,000 tons of lead and 4,500,000 oz. of silver. The construction of the zinc works in India has been suspended owing to the Government withdrawing its financial help and owing to the Tata Company being desirous of limiting its participation. Also the construction of the new smelter is deferred, and the development of the Namma coalfield. For the first time in the reports the labour position is mentioned, and the conditions revealed are not calculated to comfort the shareholders. Reference to this matter is made elsewhere in this issue. The report also mentions that the engagement of R. G. Hall as resident-manager was not renewed when his term expired in September, 1921, and that P. E. Marmion has been appointed to the position. The accounts show receipts of £1,081,380 (with the rupee at 1s. 4d.) derived from the sale of lead and silver, and a net profit of £246,770, which was carried forward.

North Broken Hill.—The report now issued covers the year ended June 30, 1921. Operations were resumed on a restricted scale when the long strike terminated on November 10, 1920, the restriction being necessary owing to the low price of and poor demand for lead, together with the high wages and costs and the limited capacity for smelting. The result of the operations from November to the end of the company's financial year was a loss of £62,242, without any provision for depreciation, taxes, or royalty. After the fire at the Port Pirie smelters of the Broken Hill

As stated on January 25, lead concentrate was sent to the Cockle Creek works of the Sulphide Corporation for treatment. During the year 43,021 tons of ore was raised from the mine, and 32,300 tons was treated at the concentrators, which produced 6,461 tons of lead concentrate, averaging 65.5% lead, 7.3% zinc, and 28.4 oz. silver per ton, and 6,010 tons of zinc concentrate averaging 48.1% zinc, 7.4% lead, and 9.6 oz. silver. The old contract by which the zinc tailing was delivered to the Amalgamated Zinc (De Bavay's) for treatment expired on April 30, 1919, a few days before the commencement of the long strike. On the resumption of operations, the company's new plant was started, and both lead and zinc concentrates are now produced. As already mentioned, the year's work ended in a loss of £62,242, but as there was another item of income, £70,370, derived from the sale of concentrates produced before the strike, there was an actual credit balance of £8,128.

Bisichi Tin.—This company was formed in 1910 to acquire alluvial tin properties south-east of Bukeru, on the Bauchi Plateau, Nigeria. Toward the end of 1920 the properties of adjoining companies, the Forum, Ninghi, and Northern Nigeria Trust, were absorbed with the object of securing greater economy in administration. The report now issued covers the year 1920. During this time the output at the Bisichi section was 133 tons of tin concentrate, and the output at the acquired properties was 128 tons. The working result was a loss of £2,498. Accompanying the directors' report is one by Lake & Currie, engineers to the company, dated October 31, 1921. H. E. Nicholls, partner in this firm, has recently returned from a visit to the properties extending over five months. This report shows that on E.P.L. 1060 of the Forum section prospecting by bores and pits has recently proved ground estimated to contain 6,747 tons of cassiterite. This discovery will have an important bearing on the future operations of the company.

Luipaard's Vlei.—This company has operated property in the far west Rand since 1888, and the control is now with the Hamilton-Ehrlich group. Operations have never been very profitable, and no dividends have been paid since 1916. The report for the year ended June 30 last shows that 206,695 tons of ore was sent to the mill, where 48,152 oz. of gold or 4.66 dwt. per ton was extracted by amalgamation and cyaniding. The gold was sold for £269,867, or 26s. 1d. per ton, the price realized averaging 112s. 1d. per oz. The working costs was £253,712, or 24s 6d. per ton, leaving a working profit of £16,154, or 1s. 7d. per ton. Other items of revenue brought the profit to £22,960, from which is deducted £17,584 allowed for depreciation. The reserve is estimated at 624,766 tons, a reduction of 77,081 tons on the year. Additional areas on the west have been acquired during the year, and these are estimated to contain 260,000 tons of ore. Connexion with these deposits is being made from the main workings on the 12th, 14th, and 17th levels. The position at the mine depends on the gold premium and on the prospect of a reduction in white wages. It is not considered likely that the cost of stores will drop appreciably.

Simmer & Jack.—This company belongs to the Consolidated Gold Fields group, and has worked an outcrop mine in the Central Rand since 1887. For the last six years or so the dividends have been small, and there is not much remaining ground to be developed other than that recently acquired from the Simmer Deep and Jupiter companies. The report for the year ended June 30 last shows that 784,200 tons of ore was mined, and after the rejection of waste, 702,000 tons was sent to the mill. The yield of gold by amalgamation was 93,474 oz., and by cyanide 67,247 oz.; in addition, 86 oz. was recovered in by-products, bringing the total to 160,807 oz. The revenue from the sale of gold was £890,831, of which £211,766 accrued from premium. The working cost was £771,580, leaving a working profit of £119,253. The yield per ton at par was 19s. 4d., and the premium 6s., making a total yield of 25s. 4d. The cost per ton was 21s. 11d., leaving a profit of 3s. 5d. It will be seen that without the premium a loss of 2s. 7d. per ton would have been incurred. The shareholders received £75,000, the dividend being at the rate of 2½%. During the year the development disclosed payable ore over 594 ft., averaging 13.7 dwt. over 33 in. The reserve at June 30 was estimated at 1,081,000 tons, averaging 5.71 dwt. over 76 in. The sinking of the Rhodes incline shaft has been completed to the 39th level. The ore from the claims acquired from the Simmer Deep and Jupiter will be hoisted through this shaft.

Glynn's Lydenburg.—This company has worked gold mines in the Lydenburg district of the Transvaal since 1895. The Transvaal Consolidated Land and Exploration Co., Ltd., are the secretaries, and the Central Mining and Investment Corporation, Ltd., has technical control. The report for the year ended July 31 shows that 40,140 tons of ore was sent to the mill, and that 5,957 oz. of gold was extracted by amalgamation and 9,347 oz. by cyanide, making a total of 15,304 oz., equal to 7.62 dwt. per ton. The revenue derived from the sale of the gold was £86,358, including premium, and the working cost was £70,853, leaving a working profit of £15,504. It will be seen that but for the premium there would have been a loss. Dividends at the rate of 8¾%, absorbing £14,875, have been distributed. The directors have adopted a policy involving a considerable increase in prospecting and development, and it is probable that for some time all the profits will be allocated to this purpose.

Gaika Gold.—This company was formed by the Rhodesian Exploration and Development Co., in 1902, to work a gold property near the Globe and Phœnix, in Rhodesia. Control passed to the Gold Fields Rhodesian Development Company in 1912. The report for the year ended June 30 shows that 40,127 tons of ore was raised and treated, yielding 9,156 oz. of gold by amalgamation and 5,824 oz. by cyanide, a total of 14,980 oz. The income derived from the sale of the gold was £82,580, of which about £19,000 represented premium. The profit was £32,613, and £34,186 has been distributed as dividend, being at the rate of 12½%. The ore reserve at June 30 was estimated at 73,000 tons, averaging 13.2 dwt. per ton, as compared with 64,000 tons, averaging 15.7 dwt. the year before. There has been much discussion lately as to whether it would not be possible to increase the tonnage and assay-value of the ore treated, but Cyril E. Parsons, the consulting engineer, is against such a policy, as he holds that the position does not warrant such an increase. At the meeting of shareholders held last month the agitators for an increase carried the day, and their leader was elected to the board. Reference to this matter is made in the Review of Mining.

BISICHI TIN COMPANY, LTD.

Directors: James Gardiner (*Chairman*), W. S. Coutts, W. Graham, H. E. Nicholls, A. H. Young. *Engineers:* Lake & Currie. *Secretary:* W. W. Evans. *Office:* 33, Cornhill, London, E.C. 3. *Formed* 1910; absorbed the Forum River, Ninghi, and Northern Nigeria Trust companies in 1920. *Capital Issued:* £372,039.

Business: Operates alluvial tin properties on the Bauchi Plateau, Nigeria.

The tenth annual general meeting of the Bisichi Tin Company (Nigeria), Ltd., was held on November 30 at the Cannon Street Hotel, London, E.C., Mr. James Gardiner (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for the year 1920, said that the delay in submitting these was due entirely to the protracted nature of the liquidation of the accounts of the absorbed companies, the final audit of which had only just been completed. The issued capital now stood at £372,039, the increase being due to the purchase consideration for the absorbed companies, full details of which were issued at the time the amalgamation was carried into effect. The item under the heading contingent liability represented a liability not in cash but in fully-paid shares in, and contingent only on, the Lancarrow property in Cornwall being floated as a separate concern. Although the item had been inserted at the request of the auditors it was in reality no liability at all. The exploration account showed an increase of about £8,500, but this was money well spent, and the progressive policy adopted by the directors in respect of acquiring new areas had been fully justified by the very large additions to reserves.

There were remarkable developments which had taken place since the occasion of their last meeting. This was dealt with in the report of their engineers, Messrs. Lake & Currie, which, for the purpose of giving the fullest and latest available information, had been brought as nearly up to date as possible. At the last annual meeting reference was made to an area then held jointly with the Forum Company, and which was now, of course, wholly their own property, which promised to develop into one of considerable value, and it was with the greatest satisfaction that he was now able to tell shareholders that these anticipations had not only been realized, but that the discoveries had been so highly important as to exceed even their most sanguine expectations. The ground in question held under exclusive prospecting licence 1060 was large in extent; to be exact, it had an area of 3·87 square miles. On a small portion of this there had already been proved by prospecting no less than 6,747 tons of concentrates (70% metal), the gross value of which, even at the price of tin ruling to-day—namely, £163 per ton—was no less than £750,000 sterling. Attention was drawn by their engineers to the fact that this was a continuous deposit, and in that respect, as far as they were aware, the largest of its nature yet discovered. At any rate, it was one of the chief, if not the most important, of the discoveries made in Nigeria. The possibilities of this area were by no means exhausted, and he had every confidence that prospecting, which was still being carried out, would eventually substantially increase the figure given.

While this discovery was, of course, the most important development during the last year, nevertheless the additions to the reserves proved on other sections of their property were by no means negligible, and a total of nearly 11,000 tons of proved reserves, with a gross value at to-day's price of the metal of almost £1,250,000 sterling, was a figure which could be viewed with complete satisfaction.

One other point was the fact that, apart from the potentialities of the very large areas of new ground yet to be tested, the possibilities of the old leases were by no means exhausted, for already in several instances payable ground had been found to exist where it was least expected. In the statement of reserves in the report no allowance was made for ground known to be payable but not sufficiently tested to enable definite calculations to be made, and therefore the figure given might be taken as a strictly conservative one. Although work had been restricted in other directions, prospecting was being continued, and also the development of the various areas by construction of dams and leats was in force, so that they might be in a position to increase output and take advantage of any improvement in the price of the metal.

Another subject to which he wished to refer was one which affected not only their own company, but also the industry as a whole. Just as in the Malay States, where, with the working out of the shallower deposits, hand labour had perforce to be superseded by mechanical appliances, so was history repeating itself in the case of Nigeria. Here, again, the more easily won tin was becoming exhausted, and what might be termed the transition stage in methods had now been reached. In future mechanical methods must be increasingly adopted, and with this would arise the serious question of motive power. This could only be effected by three agencies—namely oil fuel, coal, and water-power, the first of which was almost ruled out by its prohibitive cost, while cheap coal from the Udi field would not be available until the mining field had been connected with it by the railway now under construction, a matter, however, of some years yet. There remained the third source, and those companies who had water to generate power were singularly fortunate, and it was therefore a matter of congratulation that their own properties were very favourably situated in this respect, a fact which would undoubtedly facilitate the economic development and exploitation of their very extensive areas of ground.

In conclusion, without wishing to assume the role of prophet—indeed, he would be a rash man who would indulge in prophecies under existing circumstances—he ventured to say that when the present world-wide state of depression came to an end, as come it must, tin would be one of the first commodities to be favourably affected by the improvement, and that their company would be in a position to reap its full share of the benefits resulting from an improvement in conditions.

Mr. W. S. Coutts seconded the resolution, and it was carried unanimously.

IDA H. MINING CO., LTD.

Directors: Sir George C. Denton (*Chairman*), John Waddington, St. John Winne, A. O. Cautley. *Secretary*: F. S. [illegible]. *Office*: Blomfield House, London Wall, London, E.C. 2. *Formed* 1900; reconstructed 1920. *Capital Issued*: £46,742 in shares of 5s. each.

Business: Conducts exploration work in Nigeria.

The first annual general meeting of the Ida H. Mining Co., Ltd., was held on November 29, at Blomfield House, London, E.C. 2, Sir George C. Denton (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for the year ended April 30 last, said the directors' views on the question of the Monguna area were fully set out in the report. Personally, he thought Mr. Wham showed that a satisfactory condition of affairs existed on that part of their property, and he believed there was a good future for the company there, provided that the price of tin did not fall lower than it was at present. If, as time went on, circumstances justified the erection of the pipe-line recommended by Mr. Wham, he had every reason to believe that the development of this area would prove a success. They would notice from the report that they had some ten tons of tin in Nigeria. So far they had not sold it, because the price of the metal had been very low, but as, even at the present rate, it should realize between £700 and £800, it might be desirable to have it sent home at an early date.

He wished he could give as good an account of the Damo area. They would no doubt remember that when the Ida H. Mining Company was formed the directors had before them excellent reports on it. Unfortunately, the manager whom they sent out, and who came to them with very good testimonials, had failed to discover tin in payable quantities. Naturally, the directors had done their best to investigate matters, with the result that they found views of a very conflicting nature were held on the point. After careful inquiry the directors were not satisfied that the manager might not have been too hasty in his conclusion, and for that reason it was their intention to adopt the course mentioned in their report.

Shareholders would be aware that there were said to be very favourable prospects for gold mining in Nigeria, and in this connexion they had, through the good offices of Mr. John Waddington, been fortunate enough to secure a year's option over one square mile in what was known as the Jebba district. From information that had reached him he believed that this ground had a future before it, and he was told that an eminent geologist had formed a very favourable opinion of it and had even gone so far as to say that if the quartz shown him came from Jebba—which it did—it was the most important discovery that had ever happened in Nigeria. They had not been behindhand in this matter, and he believed that Ida H., being one of the first in the field, had the right to expect that its square mile would be very favourably situated, as selections were made in the order in which prospectors commenced operations.

So far he had refrained from referring to the very depressed conditions of all commercial undertakings at the present time and, having regard to the cost of production, the ruinously low price tin was realizing. It was a little better now, and they hoped the trouble might be only temporary and that there would be a further improvement in the tin market at an early date, but low prices had gone on for some time now and they seemed rather firmly established, he was sorry to say. It was true that the Nigerian Government, recognizing the position, had granted concessions in respect of royalties and rents which must be of great assistance to the tin industry and they were thankful to them for what they have done, but—and it was a big "but"—the railway freights were still very high—exorbitantly so, he was told—when compared with those ruling in other colonies. At present he was afraid there was not much use in agitating for a reduction, but the matter must not be lost sight of and if a favourable opportunity arose for a representation to the Government advantage should be at once taken of it and the Colonial Office approached.

Mr. C. G. Lush, the company's consulting engineer, said that the report on Damo was most disappointing to himself, because they had such men as Mr. Carpenter, who worked the property on tribute and who found it highly payable; they had Mr. Roche, a very successful miner, working his own property in Nigeria, and who had been there for some 15 years, and who in consequence of his working his own property was worth more than he was—he had made £20,000 to £30,000 in Nigeria through working tin economically—and who said this was a very good property; and then they had Mr. Speed, who said the property was good. Therefore he thought that the views of their late manager were wrong. He would remind them that in the early days of Nigeria the first men who went there said there was no payable tin in the place. He could mention dozens of mines which had been turned down in Nigeria which afterwards proved highly payable, so he thought that their late manager had made a mistake and the sooner they got another man there the better. If he might make a suggestion to the directors he would like them to select Mr. Wham, if he had the time to undertake the work. Then there was a reference made to the gold. In 1914 he went out there and saw two areas owned by the Champion Company, and he could not understand why those areas were not developed. There were places where free gold is found in the outcrop. The Champion Company took some 5,000 odd ounces of alluvial out of the river, which cut through the reef. In any other country they would have had a shaft sunk before this. However, there were great prospects for gold in Nigeria, but like other countries there would be good patches and bad patches.

Mr. R. B. Wham said that one of his main ideas in coming home was to try and push along the pipe-line, by means of which they could further prospect their Monguna leases, and also produce tin. They had a very good show out there, but it wanted further prospecting.

The resolution was seconded by Mr. St. John Winne, and unanimously carried.

INDO-BURMA OILFIELDS (1920), LTD.

Directors: Earl of Denbigh (*Chairman*), Lt.-Gen. Sir E. A. Altham, Gen. Sir Bindon Blood, H. G. Latilla, C. Perkins, R. F. M. Scott. *Secretary:* J. J. Sneddon. *Office:* Finsbury Pavement House, London, E.C. 2. *Formed* 1920. *Capital Issued:* £1,380,000.

Business: The development of oil lands in Burma.

The first annual general meeting of the Indo-Burma Oilfields (1920), Ltd., was held on December 1 at Winchester House, London, E.C. 2, the Earl of Denbigh (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts to March 31, 1920, referred to the change made by the directors in the programme of the company from what was outlined in the prospectus issued when the company was formed. The prospectus declared the policy of the company to be the development of its Yenangyaung well sites. The Yenangyaung field was well known as an oil producer, and it was from that field that most of the oil in Burma had been derived. Orders were placed both in this country and America for the heavy machinery, tools, etc., for the work to be done on these sites. Like all other companies during the year 1920 this company had great difficulty in getting delivery of the machinery and plant ordered by it, and in the meantime the local staff were able to give more attention to the company's outside areas, particularly Yenanma and Padaukpin. As a result of a detailed examination of these areas they strongly urged the board to drill trial wells on them. Mr. Davies, the company's geologist, agreed with these recommendations while not in any way receding from the opinion he had expressed as to the value of the company's Yenangyaung well sites. Information was also received from reliable sources that the production from the Yenangyaung field, as proved by recent drilling, had shown a serious decline. After giving the matter the fullest and most anxious consideration, and believing it to be in the best interests of shareholders to get oil at the earliest possible date, the directors authorized work to be started at Yenanma. The first well drilled came in with a production of 6½ barrels per day at 690 ft., against the prospectus estimate of 3 barrels. Seventeen wells had been drilled in the neighbourhood of No. 1 well, and the results were set out in their technical adviser's report. Four further wells were being drilled, and the results might be received at any time. Oil had been struck in every well, the six best giving results of 12, 14, 18, 25, 30, and 45 barrels per day respectively. Results from three wells had been cabled since the report was issued; No. 20, which produced 11¼ barrels per day, No. 21 producing 18 barrels, and No. 22 producing 30 barrels.

In the Padaukpin area, work was commenced in No. 1 well in January, 1921, and in No. 2 well some little time later. It was subsequently discovered, as the result of a large-scale survey, that the centre of the dome was situated on an area of 1·8 square miles contiguous to the company's original area. This area was the property of a Burmese syndicate, from whom the company's managing agents obtained an option to purchase at the price of £17,500, and they had now turned the whole of this area over to the company at the price they paid for it, subject only to the same royalty as is payable in respect of the original area. Five sites were located on that area, and No. 3 well struck the oil at a depth of 1,414 ft., the yield being 63 barrels per day. No. 1 well was drilled to 1,950 ft., when on account of bad caving-in it was decided to abandon it. No. 2 well had now reached a depth of 782 ft., No. 4 well a depth of 1,450 ft., and might strike the oil at any time. No. 5 had reached 705 ft., and No. 6 100 ft. The rig was erected on No. 7 well. This was very satisfactory and the company was to be congratulated in owning a property of such great possibilities.

The satisfactory results from the Yenanma and Padaukpin areas fully confirmed and justified the change of programme in making the development of these areas the principal work of the company, but the directors had no intention of allowing their valuable well sites at Yenangyaung to lie dormant. As, however, the Yenanma and Padaukpin operations could be controlled easily and satisfactorily from a central base at Thayetmyo, the starting of work at Yenangyaung would have meant the duplication of staff, stores, machine shops, etc. The company had a short time before completed negotiations with the Yomah Oil Co., Ltd., for the erection of a joint refinery, and as the Yomah Company were drilling at Yenangyaung, an arrangement was made with them to drill a number of the company's sites on a co-operative basis.

As regards the refinery, on making careful search for a suitable site, it was found that the Yomah Oil Company had already acquired the best site which could be discovered anywhere in the neighbourhood of Rangoon. That company had already ordered a considerable amount of material, and eventually it was decided to join with them in the erection of a co-operative refinery. A separate company known as the United Refineries Burma, Ltd., was registered, two-thirds of the capital being found by their company, and one-third by the Yomah Oil Company, the profits to be divided in accordance with the amount of crude oil passed through the refinery by the respective companies. The first unit of this refinery was nearing completion

Further money had to be found, particularly for the company's share of the refinery, and an issue of £250,000 ten per cent First Mortgage Convertible Debenture Stock was made at the end of September last. This was all taken up.

He was assured that taking a moderate view the company could, beginning early in the New Year, count on earning profits of £10,000 per month, which sum would be progressively increased as production increased. With regard to the future programme, work would proceed with the present plant at Yenanma and Padaukpin continuously. The company's experts have the fullest confidence in the future of the company, and so had every member of the board.

Lt.-Gen. Sir E. A. Altham seconded the resolution, and it was carried unanimously.

PREMIER OIL CO., LTD.

[illegible] F. H. Hamilton (*Chairman*), J. Fairbairn, C. Perkins, H. Auerbach, H. G. Latilla, A. Whittaker, [illegible] *Secretary*: R. Stanley Williams. *Office*: 62, London Wall, London, E.C. 2. *Formed* 1919, as a reconstruction of the Premier Oil & Pipe Line Co., Ltd. *Capital issued*: £3,197,671 10s. in shares of 15s. each.

Business: Has large holding in a French company owning oil properties in Galicia and Czecho-Slovakia.

The first ordinary general meeting of the Premier Oil Company, Ltd., was held on December 9 at River Plate House, Finsbury Circus, London, E.C., Mr. F. H. Hamilton (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts, said that when the present company was formed the Germans, or rather neutrals under German control, had physical possession of the properties in Galicia, largely through subsidiary companies or individual representatives who were entirely under their control. The old Premier Company, of which this company was the successor, was in debt to the extent of considerably over £100,000 before the war to the German groups. Subsequently this company succeeded in getting Polish sequesters appointed to carry on the business of the company. At an extraordinary general meeting of the company, held in June of last year, certain proposals for carrying through the sale to a French company were placed before shareholders, and were unanimously adopted, and the directors reported in a circular dated February 2 of this year that the arrangements, as authorized at the meeting in June, had been carried into effect, and that the French company had entered into possession of the properties early this year.

The reports upon the properties in Galicia, now published, were of very detailed character They included one report from Mr. Campbell Hunter, who was appointed as the company's representative to report independently of the French company, and another from Mr. H. Vilter, general manager of the French company. Altogether they carried things down to the beginning of October, and presented a clear and detailed picture of the position and of the progress that had been made during the first three-quarters of the year. Broadly speaking, the record was a highly satisfactory one, especially when it is borne in mind that it was only during this year that the French company assumed control. Production was increasing, an active drilling programme was being maintained, a large scheme of electrification, which would effect important economies, was making good progress, and for the months for which the French company had complete figures satisfactory profits were earned. The difficult task of reorganizing the very intricate machinery of the company had been tackled with energy and intelligence, and to-day they had a working organization absolutely second to none in Galicia.

A question of great importance—namely, the prolongation of leases—had been settled in a highly satisfactory manner. As the report showed, a certain number of the leases, the most important of which was that of the State Land Territory, had but a short time to run. In the case of the State Lands between five and six years remained—far too short a period to justify the expenditure of capital upon wells, although they were advised that the ground was rich. Owing to energetic representations made to the Polish Government, which were strongly supported by the representative of the French Government in Warsaw, the leases had now been extended for a further period of twenty years from the date of the expiration of the original lease, against a cash payment of 1,000,000 francs. Favourable arrangements had also been made with regard to the other leases, but the contract with the Polish Government regarding these State lands was of the greatest importance and should secure to the French company a large and increasing production from this source alone for many years to come. Of course, the extravagant and almost grotesque variations in the Polish exchange was a disadvantage, but this might easily be exaggerated.

As regards the relationships between the company and the French Premier Company, it might be well to point out with some precision what they actually were. They owned about 35% of the ordinary capital and about 40% of the parts de fondateurs, or, as they might be termed, the deferred capital of the company. The control of this, the English Premier Company, was, of course, vested absolutely in its shareholders. The control of the French company was secured to the French groups, not merely by the fact that they held a majority of the shares, but specifically under clauses in the agreement of sale. This company, however, had four directors upon the board of the French company, and the French company had two representatives, Messrs. Auerbach and Paix, upon this board. The relationships between the two companies were therefore of necessity very intimate, and during all the stress of the extremely difficult time through which they had been passing, and the complicated adjustments necessitated by the transfer of the properties and various contracts, the relationships had up to the present been of a frank and cordial character.

It was desirable at this meeting that they should consider very briefly the results of this transfer to the French company, with all its advantages and disadvantages in the light of the experiences of the last twelve months. The present board was responsible for it in a very special sense. They advocated the policy, found the buyers, and finally they conducted the very intricate negotiations, here and in Paris, over a period of some eight months. If the policy was a wrong one they had no one else than themselves to blame. They could best answer the question by asking what would have been the situation to-day if they had preserved the previous status. Obviously they would not have been in possession of the properties. They would still have been held by the sequesters representing the Polish Government, and they would have had not a shadow of right to control their policy. Government representatives, whether Polish or British, were not the ideal managers of any industrial enterprise, and in this case the sequesters laboured

under peculiar disadvantages. They could not find the capital to carry out the reorganization that was imperatively necessary, and they were, moreover, hampered by a rather dangerous political movement which had for its object the expropriation of the properties in the interests of Polish subjects. Had they preserved the old status they would have been deprived of the backing and influence of the French Government, which was by far the most important political factor in Poland to-day, and had been in one way and another of great service to the company, and they would not have obtained the extension of the concession on the State Lands. The only alternative way of terminating the régime of the sequesters, with all its risks, was by means of a litigation before the Arbitral Tribunal under the conditions provided for by the Treaty of Peace with Austria. There were a large number of cases still awaiting decision by that tribunal, and it seemed to them that it might well be years before their case was heard. At the best it would have been a terribly expensive process, and they would have been under the disadvantage of fighting not merely Germans, but powerful neutrals to whom the Germans had nominally at least sold and resold the control. Finally, they would at the best have been forced to repay the money which the old Premier Company owed, which would have necessitated a further reconstruction of this company, and, above all, there was only too good reason to fear that by the time they gained possession of the properties they would, in the absence of development and capital expenditure, have deteriorated enormously. Those were the factors which influenced the board in taking the line they did. It was not an easy line at the time they took it, because, apart from anything else, it necessitated negotiations in London, Paris, Berlin, Warsaw, and Switzerland, and the adjustment of a number of complicated interests; but, looking back after nearly twelve months, they had even less doubt than they had when they asked the shareholders' sanction for it that it was well worth the trouble, and that only by this means was this company saved from another and perhaps disastrous reconstruction.

The remaining question of practical importance related to their future policy. Certain shareholders had suggested to the board that as the Galician properties had been sold an immediate distribution of assets might be made. Even if that course were desirable, which in their view it was not, it was quite an impossible one at present, and, moreover, it would not be possible in any circumstances for two or three years. Under French law they, as vendors, did not receive negotiable documents of title, or, in other words, marketable shares, until two years after the registration of the company. In the meantime they were merely registered as entitled to receive certain shares in the French company. They would not be absolutely handed over to them until the end of next year. Moreover, they obviously could not distribute their 20,000 parts de fondateurs and ordinary shares of the denomination of 500 francs among their 12,000 shareholders. The only possibility was that they should sell them and distribute the proceeds over a certain term. As he had already said, that process could not be commenced for another year, and in dealing with so large an amount it would inevitably take a long time. Their own view was decisively against this policy of wholesale realization. For one thing they had high hopes of the future of the French company, and they considered that it had an excellent chance of developing into one of the most powerful and profitable combinations operating in Central Europe. It had valuable oil lands, extensive pipe-lines, a considerable portion of the refinery, strong resources, energetic management, and a strong financial and political backing. Even to talk of wholesale realizations at a period of acute depression such as they were now passing through and at a time, moreover, when the company was making rapid and substantial progress was a grave mistake. At the same time they were not blind to the advantage of some kind of capital distribution, and although nothing could be done in that direction at present, it did seem that if conditions were favourable a fairly substantial distribution might be possible, while still leaving this company with an important holding in the French company, and leaving it as an active organization apart from and outside the French company.

They had the bulk of their money on deposit at short notice, or on good security. The only important exception to this was that they had underwritten and purchased some £80,000 of 10% debentures in the Indo-Burma Oil Company. The exception was apparent rather than real, because the debentures were redeemable in three years at 110. They had no doubt either of the soundness of the security or of the wisdom of the transaction. Two of their directors—one of whom was Mr. Perkins, who was managing director of the company—were also directors of the Indo-Burma Company. They went carefully into the question of security, and they were convinced that the margin for an issue of £250,000 was ample, that the convertible rights carried by the debentures might easily become very valuable, and, of course, the return allowing for the underwriting commission and the price of redemption, was an exceptionally good one. Moreover, they had availed themselves of the opportunity of securing free of cost an option to acquire what were reported to be valuable oil-bearing areas in Burma. So far nothing had been done here, and no expense had been incurred, but they proposed almost immediately to send out the best independent experts they could secure and get their own reports upon these areas. They had reason to believe that the oil business in Burma was only in its infancy, and they had knowledge that certain important groups were actively engaged in exploitation schemes in that country. Burma had many advantages. Generally speaking, the oil was of the highest grade, was obtainable at shallow depths, and commanded a ready market. Moreover, Burma was under the British flag. The areas under offer had been taken up during the last four years, as a result of much effort, and under the best local advice available. Before embarking upon any programme of development they would send out their own experts and be guided by what they told them.

Mr. J. Fairbairn seconded the motion, and after the Chairman had answered questions from shareholders it was carried unanimously.

LUIPAARDS VLEI ESTATE AND GOLD MINING CO., LTD.

Directors: Sir Leigh Hoskyns (*Chairman*), W. Dereham, F. H. Hamilton, F. Turk. *Secretary*: W. Smith. *Office*: [illegible], 11, [illegible], London E.C. 2. *Formed* 1888, reconstructed 1896. *Capital issued*: £472,012; debentures outstanding £55,995.

Business: Operates a gold mine in the Western Rand.

The ordinary general meeting of the Luipaards Vlei Estate and Gold Mining Co., Ltd., was held on November 30 at Winchester House, London, E.C., Sir Leigh Hoskyns, Bart. (Chairman of the company), presiding.

The Chairman, in moving the adoption of the report and accounts for the year ended June 30 last, said that the improvement in the profit and loss account over the two previous years was considerable. There was a net profit of £22,960, compared with a loss during the previous year of £2,596, and a loss of £5,316 during the year before. This result was partly due to the effect of the price which was obtained for the gold, the average for the year having been £5 12s. 1·07d. It was further due to the fact that they had virtually suspended development from July 1, 1920, and it was further due to the retrenchment scheme, which, in agreement with the mine workers, was instituted in May of last year, and which had brought about a considerable reduction in the number of white men employed in the mine. The gradual reduction of working costs, both as to labour and stores, might be regarded as permanent, but development could not, of course, be suspended indefinitely, and, in fact, they had already, since July 1 last, resumed development, and were paying for it out of monthly revenue. The re-estimate made by the manager on June 30 last showed fully-developed pay ore in the mine amounting to 624,766 milling tons, of an average value of 5·20 dwt. per ton, and partially-developed ore amounting to 84,564 milling tons of pay ore, of an average value of 5·71 dwt. per ton. Although there had been crushed during the year nearly 207,000 tons, the ore reserves showed a reduction against the previous year of only 77,081 tons. The board were inclined to attach some importance to the acquisition which was made some nine months ago of twenty-two claims adjoining the property on the western side. Those claims would add some 260,000 tons of pay ore to the reserves not included in the above-mentioned figures, and adding those twenty-two claims to the ore reserves in other parts of the mine they had a total reserve representing nearly four years' crushing. It was the intention to give increased attention in the near future to the development of the Battery Reef sections of the property. This company, together with all the low-grade mines on the Rand, had been passing through several years of acute depression, but there was every reason to think that the clouds were passing.

Mr. W. Dereham seconded the motion, and the report and accounts were adopted.

WITBANK COLLIERY, LTD.

(*Incorporated in the Transvaal.*)

EXTRACTED FROM THE ANNUAL REPORT
for the Year ended August 31, 1921.

Issued Capital, £350,000 in 350,000 Shares of £1 each.

Directorate: Sir Harry Ross Skinner, Kt., M.Inst.C.E. (*Chairman*), Sir Evelyn Wallers, K.B.E., E. G. Izod, M.B.E. (*Managing Director*), Major C. S. Goldman, P. Dreyfus, Sir Abe Bailey, Bart., K.C.M.G., M.L.A., J. Jeppe, C.B.E., H. A. Rogers.

		£	s.	d.
Total profit for the year		155,952	9	3
Balance unappropriated at August 31, 1920		97,751	0	10
Making a total of		253,703	19	1
This amount has been dealt with as follows:—				
Expended on Capital Account less Sale of Township Stands and Freehold Property (£7,765 18s. 1d.)	£14,034 9 1			
Government Taxes	17,217 2 8	31,251	11	9
		£222,451	18	4
Dividends declared during the year:—No. 32 of 17½% and No. 33 of 15%		113,750	0	0
Leaving a balance unappropriated of		£108,701	18	4

During the year 1,117,680 tons, including 105,277 tons of duff, were despatched from the Colliery, being an increase of 122,091 tons as compared with the previous year.

The full Report and Accounts may be obtained from the London Secretaries, A. Moir & Co., 1, London Wall Buildings, London, E.C. 2.

NEW MODERFONTEIN GOLD MINING COMPANY, LIMITED.

Directors : Sir Evelyn Wallers (*Chairman*), J. R. Leisk, Sir H. Ross Skinner, J. G. Currey, C. S. Goldman, S. C. Black, R. W. Fennell, W. T. Graham. *Secretaries :* Rand Mines, Ltd. *Head Office :* Johannesburg. *London Office :* 1, London Wall Buildings, E.C. 2. *Formed* 1888. *Capital :* £1,400,000.

Business : Operates a gold mine in the Far East Rand.

The twenty-fourth ordinary general meeting of New Modderfontein Gold Mining Co., Ltd., was held in Johannesburg on November 4, Sir Evelyn Wallers, K.B.E., presiding.

The Chairman, in moving the adoption of the report and accounts for the year ended June 30 last, said that the position must have given shareholders the greatest satisfaction. The scale of operations and the total working profit derived from those operations were the greatest ever obtained by the company. They milled during the year 1,083,000 tons, yielding 9·741 dwt. per ton, representing an increase in tonnage milled of 114,500, and a decrease in grade of 0·58 dwt. per ton. The latter point was a desirable feature of the year's work, because, although the value of the ore mined was still somewhat above the average value of the ore reserves, it was decidedly below the average value of the tonnage developed during the year. The number of fine ounces recovered was 527,477, with a total extraction of just under 98%, which constituted extremely good metallurgical practice. The price obtained for the product was appreciably higher than for the previous year, namely, £5 12s. 7d. per fine ounce, as against £5 2s. 3d. for 1919-20. Obviously this factor had a very marked effect upon the profit. Working costs increased by 1s. 6d. per ton milled, but notwithstanding this fact, combined with the decrease in yield of 0·58 dwt. per ton, the final working profit showed an increase of 7d. per ton. The total profit for the year was £1,720,202 17s. 4d., of which £751,427 was obtained from the increased price of the product above standard price. The appropriation account showed that they commenced the year with a credit balance of £344,025 13s., and this amount added to the year's profit and including a small amount of £763 12s. 9d. in respect of forfeited dividends, gave for disposal a total of £2,064,992, 3s. 1d. The distribution had been as follows :—

	£	s.	d.
Dividends Nos. 29 and 30 .	1,400,000	0	0
Government and Provincial Taxes	297,950	9	5
Net Capital Expenditure after allowing for Bewaarplaatsen receipts . .	60,193	3	7
Balance unappropriated and carried forward . .	306,848	10	1
	£2,064,992	3	1

Development operations during the year were carried on with activity, and showed a substantial increase as compared with the preceding year. The total footage was 20,165, of which approximately 14,000 ft. developed ore, and the remaining 6,000 ft. was in the nature of dead work and the various purposes connected with the handling of the ore. The results achieved by this work in all directions were entirely satisfactory as to the values exposed. They had from time to time directed attention to the encouraging values which were likely to be met with in the western and south-western sections of the mine, and the work which they were able to do year by year confirmed in a very gratifying way the opinions expressed. Thus, on the 13th level west good values were disclosed after passing through a dyke and were referred to at the last annual meeting. These values had been energetically followed up during the year which he was reviewing, and resulted in the development in that locality of 302,800 tons of ore of a value of 9·7 dwt. over 82 inches. On the eastern side of the mine the result of the work carried out was equally satisfactory, and the final outcome of the year's development operations was that all ore mined was replaced, and, indeed, the ore reserves at 8,884,600 tons of a value of 8·4 dwt. showed some little increase in tonnage when compared with the previous year.

The total available area of the mine was 1,264 claims. Of these, 361 claims were worked out, but still contained a number of valuable pillars; 378 claims represented the intact developed area, and 525 claims still remained to be developed. In other words, about 28% of the property had been worked out, and 72% remained, which included, of course, the developed area representing 30%.

The health conditions of the mine were in first-class order, having been commented on by the District Inspector of Mines in very appreciative terms, and he could say with the utmost confidence that the general underground position was in most excellent shape. On the surface a similarly gratifying situation was met with. The increase to the eastern reduction plant, which brought their total capacity up to at least 105,000 tons per month, was completed during the year, at the very moderate cost of £14,000 and was now running well.

The other items of importance on capital expenditure were £22,000 expended in providing additional houses for married employees, and £16,700 for extension to their water system. In regard to this latter item they had had some anxiety in the dry season owing to the fact that the number of consumers, of whom they were one, drawing water from the President Dam had appreciably increased. They therefore considered it prudent to spend this money on making the position secure, by connecting up their storage reservoirs with the Rosherville Dam. For the current year no capital expenditure of any particular importance was contemplated.

In order to bring the information up to date, he would briefly review the salient features of the work since the close of their financial year, that was during the last four months. The native labour force had continued to hold up well, and their tonnage milled had steadily progressed. In July the figure was 96,000; August, 100,000; September, 101,000; and in October they reached a total of 107,000. Working profits had been respectively £141,800, £153,100, £142,900, and £138,000. There was naturally some decrease in profit, due to the

[illegible] realised for the price of gold, but the [illegible] the reduction in the price of their product had been counteracted in a very satisfactory way by the increase in the tonnage milled. Working costs over the last four months had shown an encouraging decrease; the figures for the respective months per ton milled were 22s. 9d., 22s. 4d., 22s 2d., and 21s. [illegible], compared with the average for last year of 23s. 5·5d. The development work since July last had also been very energetically pushed, and they had averaged well over 2,200 ft. per month. The values exposed on the whole had been of high grade, both east and west. There were four winzes not yet very far advanced going down from the 14th level and constituting their present lowest workings, two on the west side of the circular shaft and two on the east side; three of those winzes were exposing ore of an average value of approximately 1,000 inch-dwt. At the present footage rate practically the whole of the mine above the 14th level would be completely developed in about two years' time, and the scheme for the development of the mine below the 14th level to the southern boundary was already receiving attention, although there was ample time in which to formulate their plans. In any case the problem was one of comparative simplicity. Considerable attention was being given to the cleaning up of the old workings, and to facilitate this work a sand-filling scheme of some magnitude was now being put in hand on the upper levels on the east of the mine; at the same time opportunity would be taken to further prospect a few isolated blocks of ground which had been left standing in the past as of doubtful payability.

At the last annual meeting reference was made to the question of the enemy shares vested in the Custodian of Enemy Property. The company made an offer for those shares, which was not accepted. They, therefore, still remained in the hands of the Custodian, but shareholders might rest assured that the directors were carefully watching the situation, and if there was any possibility of acting in their interests on a satisfactory basis, the opportunity would not be lost.

All that he had said indicated again in an unmistakeable manner not only the extraordinary soundness and strength of position of the mine, but also the excellence of the year's work of the general manager, Mr. Miles Sharp; the underground manager, Mr. Tillard, and the staff and employees generally. Mr. Stuart Martin continued to act as the consulting engineer with conspicuous success. Shareholders would, he was sure, join with him in recording their very keen appreciation of their services.

Mr. S. C. Black seconded the motion, and it was carried unanimously.

NOURSE MINES, LIMITED.

Directors: E. G. Izod (*Chairman*), W. T. Graham, H. Nourse, A. L. Mallins, W. Dereham, G. S. Hutt, Sir Evelyn Wallers, S. C. Black, L. J. Renaud, E. Raleigh. *Secretaries:* Rand Mines, Ltd. *Head Office:* Johannesburg. *Formed* 1894. *Capital issued:* £827,821.

Business: Works a gold mine in the central Rand.

The twenty-fifth ordinary general meeting of Nourse Mines, Ltd., was held in Johannesburg, on November 4, Mr. E. G. Izod, M.B.E., presiding.

The Chairman, in moving the adoption of the report and accounts for the year to June 30, said that the profit earned was £118,347, a substantial increase of £30,377 over the figure for the preceding year. In spite of a slight fall of 0·146 dwt. in the yield, working revenue increased from 33s. 1d. to 35s. 6s. per ton milled, due entirely to the higher price obtained for the gold. Working costs increased by 1s. 5d. per ton milled, due very largely to the increased cost of stores, the amount spent under this heading being £49,845 in excess of that spent for the previous year. In his last speech he referred to the attention which was being given to the water position. On a mine like the Nourse, with what was virtually an abandoned outcrop mine above it, the problem of dealing with water was always a serious one. With the completion of the centrifugal pumping unit they were able to deal with all their present water and have a substantial margin in hand for emergencies. Realizing, however, that further precautions might be taken to minimize the water danger, they investigated the surface of the New Heriot, which mine ceased pumping operations more than twelve months ago. They decided that if they could obtain control of the water-right on the New Heriot, together with certain surface claims, which were for disposal, they could probably prevent a large amount of surface water from entering their workings, and they accordingly purchased for £5,500 the claims and water-right mentioned. By suitable attention to the surface of the ground so acquired, they had been able substantially to reduce the water handled by their pumping plant, and the saving in pumping costs had already been more than the expenditure on the acquisition of the claims and water-rights.

The profits earned for July, August, September, and October of this year totalled £34,274. Working costs at an average of 31s. 9d. per ton milled were higher than the average for the financial year covered by the report and accounts, and it was only the maintenance of the high price obtained for the gold that had enabled them to make profits. Work on the programme in connexion with No. 1 shaft South Nourse was proceeding satisfactorily. This shaft reached the horizon of the 27th level in July, and the 27th level cross-cut had already advanced approximately 130 ft. out of a total of about 800 ft. necessary to strike the reef. The 25th level cross-cut from this shaft had advanced 80 ft. and was expected to strike the reef at about 350 ft. from the shaft. The new large Ward-Leonard winder on the surface at this shaft had been working satisfactorily. Development continued to be promising. On the western side of the mine, in the No. 2 South Nourse section, the Main Reef Leader disclosures were good.

Mr S. C. Black seconded the motion, and it was carried unanimously.

CHINESE ENGINEERING AND MINING CO., LTD.

Directors: W. F. Turner (*Chairman*), F. Cattier, Edmund Davis, E. de Wouters, E. Francqui, L. Jadot, Col. H. A. Micklem, Lord Southborough. *Agent and General Manager in China:* Major Walter Nathan. *Secretary:* A. W. Berry. *Office:* 22, Austin Friars, London, E.C. 2. *Formed* 1912. *Capital issued:* £1,400,000; debentures £1,008,000

Business: Operates coal mines in North China; is also interested in iron deposits.

The ninth annual ordinary general meeting of the Chinese Engineering and Mining Co., Ltd., was held on Monday, December 12, at Winchester House, London, E.C., Mr. W. F. Turner (Chairman of the company) presiding.

The Secretary (Mr. Alfred W. Berry) having read the notice convening the meeting and the auditors' report,

The Chairman said: The distinguishing feature of the report and accounts for the year ended on June 30 last, which we submit to you to-day, is that, while owing mainly to the fall in the average rate of exchange, they deal with smaller figures than those of the preceding year, the net result is equally satisfactory. For the year ended June 30, 1920, we paid a dividend of 30%, free of income tax, on a share capital of £1,000,000. The balance dividend of 12% which we propose to declare to-day will make, with the interim dividend of 10% paid in May last, a total of 22%, free of income tax, on the increased capital of £1,400,000, so that we shall be distributing £308,000 in dividends, against £300,000 in the preceding year. It must be borne in mind that the 400,000 new shares did not constitute any addition to the working capital of the company. It was merely the capitalization of profits which had accumulated during past years.

The net profit of the Kailan Mining Administration, after providing for interest on the 6% Kailan bonds, redemption of bonds for the year, reserve for depreciation, and the profit to which the Chihli Government is entitled, was $7,313,448, against a net profit of $8,917,456 for the preceding year. This result, as you will have seen from a later paragraph in the report, is due, not to any falling off in the demand for coal, but solely to difficulties in regard to railway transport, and it compares very favourably with the profit of about $6,000,000 two years ago.

Our share of the profit amounts to $3,850,012. We were careful to point out to you at the meeting last year that the profits of that year had been largely increased by the high rate of exchange which had prevailed throughout the year. The average rate for the past year shows a reduction of about 2s. per dollar, and the amount brought to credit of our profit and loss account therefore works out, including interest in China, at £564,723. Interest in Europe is £72,221, and there are some small items which bring up the total to £641,469.

Expenses in Europe are larger than before, as I told you they would be. There is a donation of £5,000 to the China Famine Relief Fund, which was reported at the last meeting; exchange amounts to £16,259, and there is a loss of £11,942 on the sale of 5% War Loan. Two of these items, amounting to nearly £17,000 will not recur. The net balance of profit on the year is £587,994.

You will find a statement in the accounts showing the disposal of the profit balance at June 30, 1920, the chief items being the final dividend, which was £200,000, paid on December 17, 1920, and the £400,000 which was applied in making fully paid the 400,000 shares of £1 each allotted on May 12 last, pursuant to the resolutions of the extraordinary general meeting held on January 4, 1921; the £37,784 remaining is brought into the following year. We have, therefore, a total credit to profit and loss of £625,779. Income tax absorbs £112,316, excess profits duty requires £122,304 to bring up the reserve to the required figure of £189,000, and corporation profits tax is £26,600. These three items, making a total of £261,220, form our contribution to the Inland Revenue, and, as you see, they amount to almost exactly 45% of the year's profit. The interim dividend of 10%, free of income tax, paid on May 23 last, was £140,000, so that we have a balance of £224,559 to deal with to-day.

I have already said that we propose to declare a balance dividend of 12%, free of tax, payable to-morrow, the 13th instant. The further remuneration to which the directors are entitled under the Articles of Association is £9,133, and we propose to write off the whole of the expenses in connexion with the increase of capital (consisting chiefly of stamp duties), amounting to £25,685, so that there will be a balance of £21,740 to be carried forward to the current year. This result is more gratifying when one bears in mind that the profits have had to bear a charge of £122,000 for excess profits duty, and that the company's liability to that impost ends with these accounts. The company will have paid in all for excess profits duty over £1,400,000.

As regards the balance sheet, there are only one or two items to which I need refer. The first is the increase of the share capital from £1,000,000 to £1,400,000. On the other side of the account you will see that our loan account to the Kailan Mining Administration has been increased from £50,000 to £152,000, a sum of £102,000 having been provided by us and a similar amount by the Lanchow Mining Company for further working capital of the Kailan Mining Administration. It is quite likely that we may very shortly have to contribute another £100,000 of working capital.

The next paragraph of the report relates to excess profits duty and the directors' remuneration. There is a provision in the Finance Act of 1916 to the effect that a company may recover from the directors the amount of excess profits duty payable by the company in respect of any increased remuneration above a certain limit. The object of the section was to prevent salaries or remuneration of employees or directors being increased capriciously for the purpose of reducing a company's liability to excess profits duty. No consideration of that sort arises here. The effect of the section in our case would be to defeat, to a certain extent, the object of the resolutions passed by the shareholders last year, and it would operate inequitably as between the individual directors who are concerned. The amount involved is about

[illegible]. It is [illegible] proposed that the section [illegible] not be acted upon.

The next paragraph deals with the business done by the Kailan Mining Administration during the year. The sales of coal amounted to 3,775,000 tons, a [illegible] of 235,000 tons compared with the preceding year. This is not due to any falling off in demand for coal. It is entirely a question of railway transport.

Major Nathan reports as follows: "The reduction recorded in sales is due to the following reasons: The internal troubles which occurred in the latter part of the last financial year and the beginning of this affected the transportation of coal for nearly six months, military interference on the railway and movements of troops decreasing the number of cars available for the coal traffic. No sooner were the troubles due to these causes overcome than the famine in Central China was again responsible for a reduction in our coal traffic, owing to the demands made on the railway for the export of grain from Manchuria for the relief of famine sufferers. These two reasons alone were sufficient to cause the reduction in sales which has been experienced during the year. The actual carrying capacity of the railway has not been greatly increased, the supply of trucks and locomotives having been practically stationary during that period. At the present time conditions are still unsatisfactory, although there is an improvement on our experience in the early part of the financial year under review. Towards the end of the financial year a great improvement was noticeable, largely due to the use by the Peking-Mukden railway of cars belonging to the Peking-Hankow line, and for a short period we were able to move by rail an average of about 15,000 tons per day. As a result of a traffic conference between the various lines the supply of these cars has been much reduced and the average at the present moment may be said to be about 12,000 tons per day, including a traffic of about 1,000 to 1,500 tons per day carried by our own cars to Hsukochwang and Hanku, from whence the coal is shipped by boat to Tientsin. We were enabled to increase our traffic in this way by a purchase of 200 small cars from the railway which they had thrown out of use. The burden of my monthly reports, as will have been noticed, has practically always been the same, namely, the want of cars and consequent inability to keep pace with the demand. It has been my great endeavour to persuade the railway to double the track between the mines and Chinwangtao and to purchase sufficient rolling stock to meet our demands for transport facilities, and I am pleased to say that I have at last been successful in inducing the authorities to carry out the doubling of the track and also the supply of further locomotives and cars. The effect of the latter will be seen, I hope, towards the end of the present calendar year, but that of the former, I anticipate, not before the end of 1922 at earliest."

Now as regards the prospects of the current year, Major Nathan writes: "Sales of coal have been limited only to our transport facilities, and therefore no comparison can be made with former years as to the possibility of increase if facilities had been available for the transport of our coal by rail to Chinwangtao to meet the demand. It can only be said that we were obliged to neglect or entirely abandon any attempts to develop our overseas market. The same condition will apply to a certain extent during the present year, but the quieter conditions now prevailing in the country will undoubtedly have the effect of allowing of a considerable increase in our sales compared with last year. At the time of writing, in the first three months of the financial year 1921-22, our sales have augmented by a quarter of a million tons as compared with the same period in 1920-21. Although these figures are not likely to be maintained throughout the whole year, there is no reason to expect that our sales will not be considerably higher than in the year under review."

The stock of coal at the latest date we have was about 370,000 tons. Our output capacity is 15,000 tons daily, and Major Nathan states that, given fair labour conditions, he has every expectation of reaching a total production of over four and a half million tons during the current financial year. The coal in sight at June 30 last is given as 24,435,000 tons. The yards at the port of Chinwangtao have been extended to allow the handling of 15,000 tons of coal per day and the storing of 260,000 tons. The sales of coal during the first twenty-three weeks of the current year amount to 1,841,000 tons, as compared with 1,521,000 tons for the same period last year, an increase in round figures of 320,000 tons. The average rate of exchange for the present financial year, so far as it has gone, is approximately 2s. 9d. per dollar, and does not differ materially from that of the preceding year. The business prospects, therefore, are entirely satisfactory.

At the last general meeting we explained at some length the position of matters in regard to the project for the establishment of iron works at Chinwangtao. The matter has been followed up throughout the past year and considerable progress has been made. Mr. David Roberts, of Cardiff, who is a well-known blast-furnace engineer, went out to China on behalf of Messrs. Riley & Harbord, to inspect and decide upon the best available site for the proposed works. A satisfactory site has been chosen, and the necessary arrangements in regard to it are in progress. Further investigations are proceeding, especially in regard to certain deposits of iron ore and the treatment of them. These may still take a considerable time, and until they are completed a definite scheme cannot be formulated and adopted. In the meantime the prices of labour and materials are falling, and it is expected that there will be a saving of several hundred thousand pounds in the ultimate outlay for plant, compared with the figures which we had before us a year ago. I now move: "That the directors' report and accounts to June 30, 1921, be, and they are hereby, received and adopted, and that a final dividend be declared of 12%, free of income tax, making 22% for the year, free of income tax, payable on December 13, 1921."

Colonel H. A. Micklem, C.B., C.M.G., D.S.O., formally seconded the resolution, which was then put to the meeting and carried unanimously.

The retiring directors (Mr. Félicien Cattier, Colonel H. A. Micklem, and Mr. W. F. Turner) having been re-elected, and the auditors (Messrs. Annan, Dexter & Co.) reappointed, the proceedings terminated.

SOUTH WEST AFRICA CO., LTD.

Directors: Edmund Davis (*Chairman*), Sir Henry Birchenough, F. Eckstein, D. O. Malcolm, H. P. Rudd, Admiral Sir E. J. W. Slade. *Secretary:* C. Launspach. *Office:* 1, London Wall Buildings, London, E.C. 2. *Formed* 1892. *Capital:* £2,000,000 ; issued £1,750,000.

Business: Owns land, mining, and railway rights in Damaraland, South West Africa.

The annual general meeting of the shareholders in the South-West Africa Company, Ltd., was held on December 6, at Winchester House, London, E.C., Mr. Edmund Davis (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report, said that their original claim in respect of amounts held on deposit in Berlin, and sums which accrued to the company during the war period, had been dealt with at various dates. Their concession was a direct grant from the German Government, and covered such extensive rights that at a later date the company agreed to some modifications, and, in exchange for the rights they waived, were granted joint interest with the German Government in the mineral rights of Ovamboland, a territory covering about 20,000 square miles. It was, therefore, impossible to understand how the Union Government of South Africa, which held a mandate over South-West Africa, could justify their action in confiscating the mineral rights covered by the company's concessions. As shareholders were aware, the Government had cancelled the whole of the company's rights with the exception of its title to about 1,600,000 acres of freehold land and a certain exclusive right in regard to mineral areas. The accounts presented on that occasion were up to December 31, 1920, but, of course, they in no way reflected the position as at to-day's date. In those circumstances the directors desired to set out what would probably be the position as soon as effect had been given to the transaction relating to payments under their claim and to the purchase of shares by the company. In the first instance they might take it for granted that at any rate 1,200,000 of their shares would be acquired by the company, though the actual number might be slightly in excess of that figure. Those shares had been acquired from the Public Trustee at 11s. 6d. per share, with a formal approval of the Board of Trade, which was subject to passing the necessary resolution adopting new articles of association. Taking the figure 1,200,000 shares as being correct, those would be added to the unissued capital, thus reducing the issued capital to £560,000 in shares of £1 each. Against that capital they would have their British, Colonial, and foreign—other than German and Hungarian—investments, which at to-day's market price were worth about £516,000. To that should be added other items bringing the total to £673,027. Of course, due consideration would be given when framing their next accounts to the land sales account, which was really a reserve account, and stood at £84,503, and their balance of profit £95,238.

Mr. F. Eckstein seconded the resolution, which was carried.

Professional Directory

ADCOCK, S. R.,
Metallurgist, Assayer, and Sampler,
Atlas Court, St. Helens, Lancs.

ADDICKS, Lawrence,
Consulting Engineer,
51, Maiden Lane, New York.
Cables: Galie, New York.

Tel.: 3700 London Wall.
AGNEW, John A.,
Mining Engineer,
1, London Wall Buildings, London, E.C. 2.
Cables: Lingulina, London.

AGUILAR-REVOREDO, J. F.,
Consulting Mining Engineer
Examination, Valuation and Development of Mines in Bolivia. Casilla 176, Oruro, Bolivia.
Cables: Revoredo, Oruro. Usual Codes.

ALDRIDGE, Walter H.,
Mining and Metallurgical Engineer,
41, East 42nd Street, New York.

ALLEN, Reginald F.,
Mining Engineer,
Tin and Gold, Lode and Alluvial,
Kingsdown (Hewas Water) Tin Mines, Ltd.,
St. Austell, Cornwall.

ATTENBOROUGH, Leonard G.,
Mining Engineer,
Speciality: Alluvial Tin.
Ipoh, Perak, Federated Malay States.
Code: McNeill 1908

BAIN, H. Foster,
Mining Geologist,
Director U.S. Bureau of Mines,
Washington, D.C., U.S.A.

J. W. TEALE. H. H. YUILL. Tel.: London Wall 3667.
BAINBRIDGE, SEYMOUR, & Co.,
Mining Engineers, Ltd.,
645–647, Salisbury House, London Wall, E.C. 2.
Cables: Basera. Usual Codes.

ROGERS, MAYER, & BALL. Cable: Albasters.
BALL, Sydney, H.,
Mining Geologist,
42, Broadway, New York.
201, Devonshire Street, Boston.

BANKS, Charles A.,
Mining Engineer,
612, Pacific Building, Hastings Street, W.,
Vancouver, B.C.
Cables: Bankca. Code: Bedford McNeill

BATTEN, H. L.,
Mining Engineer,
614, Pender Street, W., Vancouver, B.C.
Cables: Alamorg. Code: Bedford McNeill.

BEATTY, A. Chester,
25, Broad Street, New York.
No professional work entertained.

BELLINGER, H. C.,
Metallurgical Engineer,
Chile Exploration Co.,
120, Broadway, New York.

BLANKINSHIP, J. W.,
Consulting Plant-Pathologist.
Speciality—
Smoke and other Industrial Injury to Vegetation.
2525, Hilgard Ave., Berkeley, California, U.S.A.

BOISE, Charles W.,
Mining Engineer,
Foreign Exploration,
Room 1507—14 Wall Street, New York.
Cables: Mukeba.

BOTSFORD, R. S.,
Mining Engineer,
Room 2083, 50, Church Street, New York City.
2, Drapers Gardens, London, E.C. 2.

BOYLE, Vicars W.,
Mining Engineer,
24, Coleman Street, London, E.C. 2.

Tel.: London Wall 6940.
BROADBRIDGE, Walter,
Chief Engineer,
Minerals Separation, Ltd., 62, London Wall, E.C.
Cable: Rillstope, London.

BRODIE, Walter M.,
Mining Engineer and Metallurgist,
47, Cedar Street, New York.

Tel.: London Wall 2776.
BROWN, R. Gilman,
Mining Engineer,
Pinners Hall, London, E.C. 2.
Cable: Argeby. Usual Codes.

BROWNE, Spencer C.,
Mining Engineer,
2, Rector Street, New York City.
Cables: Spenbrowne, New York.

BURCH, HERSHEY, & WHITE.
BURCH, Albert,
Consulting Engineer,
Crocker Building, San Francisco.
Cable: Burch. Usual Codes.

BURCH, H. Kenyon,
Consulting Engineer,
Concentrating Department,
Phelps Dodge Corporation,
Warren, Arizona.

CALLOW, J. M.,
Pres. General Engineering Co.,
Consulting Metallurgical Engineers,
Room 3022 No. 120, Broadway, New York.
159, Pierpont Street, Salt Lake City, Utah.

DONALD F. CAMPBELL. W. S. GIFFORD.
CAMPBELL & GIFFORD,
Consulting Engineers,
Hydro-electric Development & Electro metallurgy,
17, Victoria Street, London S.W.1.

CAMPBELL, J. Morrow,
Mining Geologist and Engineer,
Messrs. Steel Brothers & Co., Ltd.,
Rangoon, Burma.

CANNING, A. R.,
Mining Engineer,
P.O. Jos,
Nigeria.

CHANNING, J. Parke,
Mining Engineer,
61, Broadway, New York.
Code: Bedford McNeill.

CLAUDET, F., Limited, Tel.: Central 1100.
Assayers and Samplers,
6, Coleman Street, London, E.C.2.
Cable: Assaying Ave. Usual Codes.

COBBE, H. N. G., Tel.: Victoria 2944.
Mining Engineer,
Albany Chambers, 86, York St., Westminster, S.W.1.
(Renamed 1920, Petty France.)
Cables: Trainable. Usual Codes.

COLLBRAN, Arthur H.,
Mining Engineer
Seoul, Korea.

COLLINS, George E.,
Mining Engineer,
Boston Building, Denver.
Cable: Colcamac. Code: Bedford McNeill.

Tel.: London Wall 2778.
COLLINS, Henry F.,
Mining and Metallurgical Engineer,
66, Finsbury Pavement, London, E.C.2.

COLLINS, W. F.,
Consulting Mining & Metallurgical Engineer,
Peking, China.
Cables: Collins, Peking.

CRANSTON, Robt. E.,
Mining Engineer,
1213, Hobart Bdg., 582, Market St., San Francisco,
and 2, Rector Street, New York.
Cable: Recrans. Code: McNeill, 1908.

F. A. CUTTEN, W. H. CUTTEN. Tel.: Holborn, 503.
CUTTEN, Brothers,
Alluvial Dredging & Mining Engineers,
Bank Chambers, 329, High Holborn, London, W.C.1.
Cables: Nettuc, London. Usual Codes.

DAVIDSON, A. A.,
Mining Engineer,
Associated Nigeria Tin Mines, Ltd.,
Jos, Northern Nigeria.

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